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ILLUMINATING ENGINEERING

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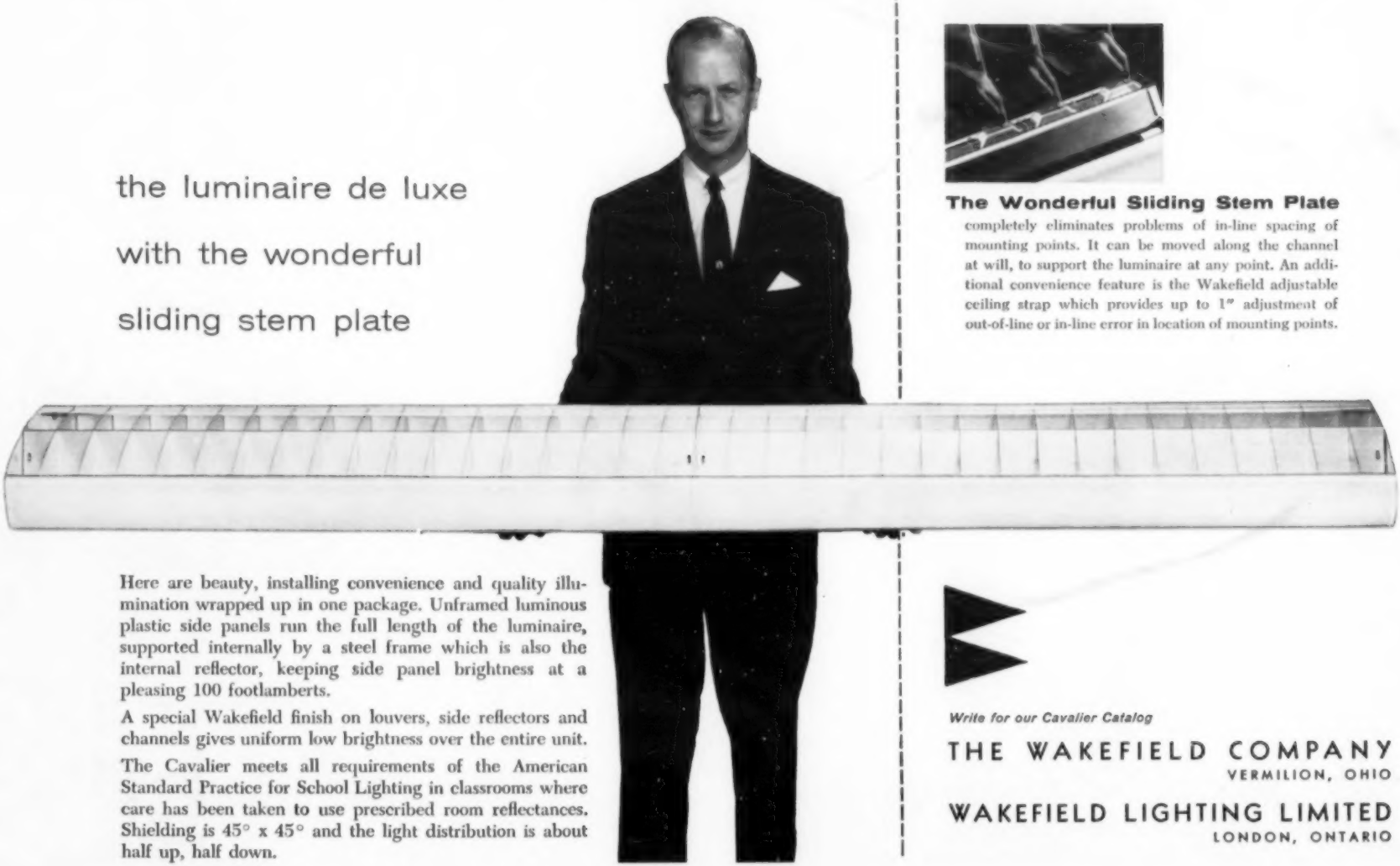
the luminaire de luxe

with the wonderful

sliding stem plate



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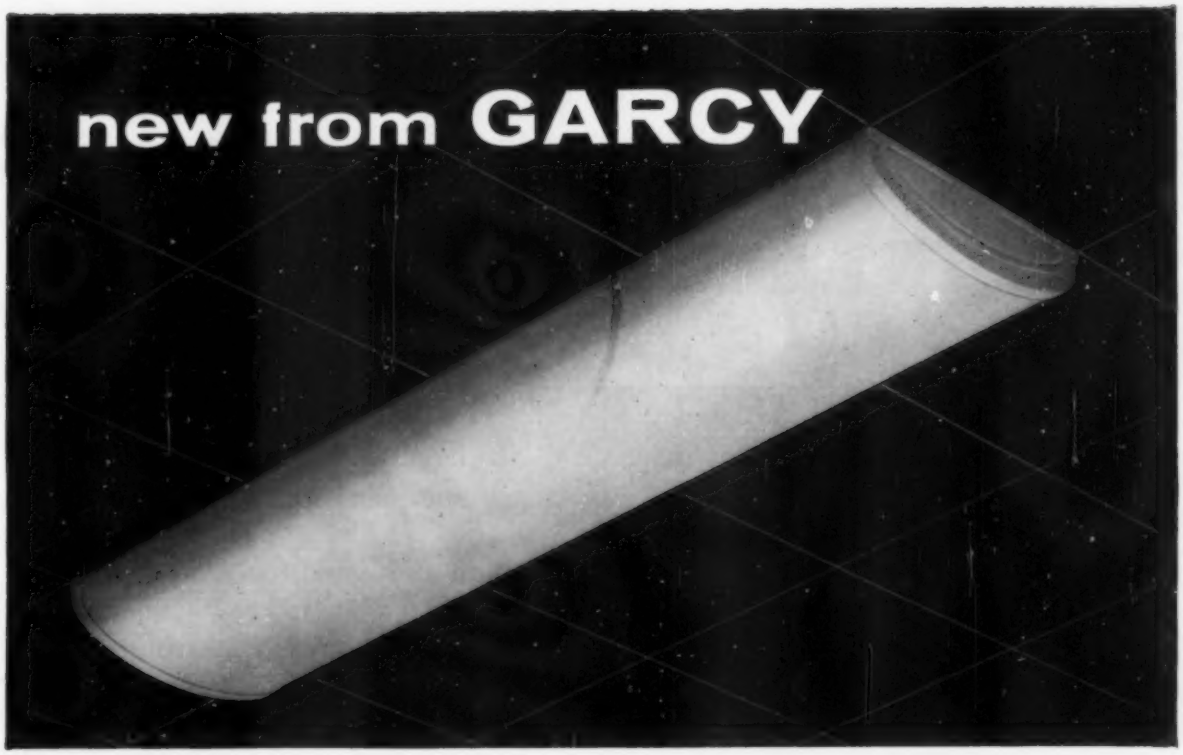

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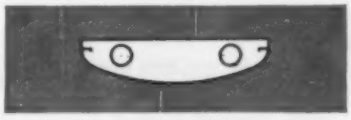

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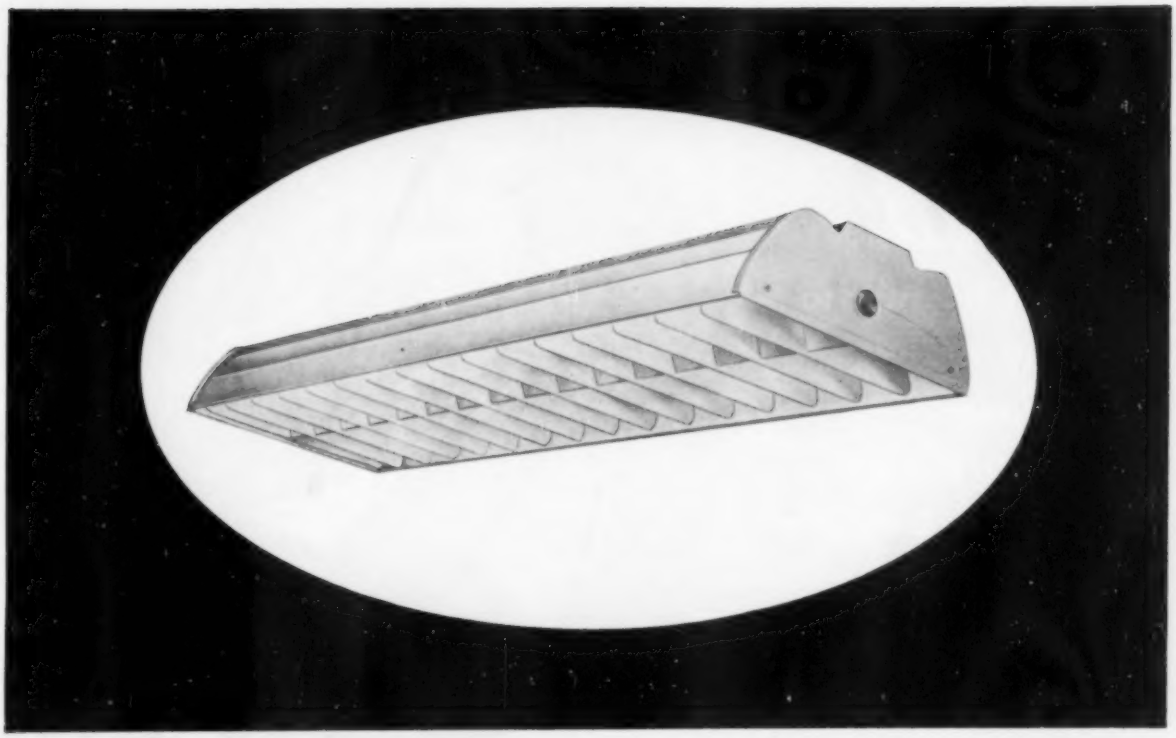

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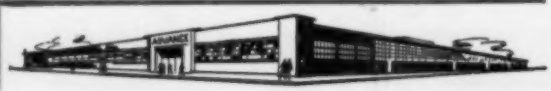

Daylighting Design With Adjustable Horizontal Louvers

By J. W. GRIFFITH
E. W. CONOVER
W. J. ARNER

This paper is the result of an adjustable horizontal louver study conducted by the Daylight Study Project at Southern Methodist University under the sponsorship of Fenestra, Incorporated and Libbey-Owens-Ford Glass Company. It presents a method of predicting daylight illumination on the work plane of rooms using adjustable horizontal louvers as a means of daylight control.

THE PROBLEM of daylighting studies on rooms employing adjustable horizontal louver controls is somewhat more complex than previous daylight studies conducted during the past eight years on this project. Since daylighting designs with adjustable horizontal louvers have an infinite number of possibilities, certain basic limitations and considerations must first be determined.

1. *Source* — As with any other daylighting design, the sun is the primary source of illumination with the sky and reflected light secondary sources. The distribution of illumination within a room varies for direct and reflected sources in such a manner that it is necessary to consider them separately.

In considering the illumination distribution from the sun incident on fenestrations employing adjustable horizontal louvers, it is necessary to take into account the intensity of the illumination, the sun altitudes, and the sun azimuth. For practical purposes, this study has been based on the incident illumination on the plane of the fenestration. The sun altitude has been considered at 30 degrees, 45 degrees, and 60 degrees in conjunction with horizontal louvers set at 30, 45 and, 60 degrees for each solar altitude. It was found that the illumination distribution on the work plane of the room varied, within limits, directly with the incident illumination at each sun altitude for various sun azimuths with respect to the plane of the fenestration. Consequently, the effect of sun azimuth is taken into account by the Cosine Law in computing the incident illumination from the sun.

The illumination distribution from clear skies is a relatively small amount of the total illumination for installations with sun on the fenestration and can be considered at the same time as the sun. For computations involving the use of adjustable horizontal louvers with no sun incident on the fenestration, the illumination distribution from the sky must be considered separately.

The illumination distribution from a uniform source below the horizon is considerably different than that from above the horizon and must be considered separately for the various louver angles.

2. *Louver geometry* — Due to time limitations, it was necessary to pick a group of fixed conditions for this study. Louvers with the inside edge of the blade tilted up 30, 45, and 60 degrees from the horizontal were used. A slat reflectance of 70 per cent was chosen as representative of typical venetian blinds. A ratio of the width of the slats to the spacing, of 1.25 was selected as typical and the slat thickness was that of a typical wood venetian blind.

3. *Fenestration* — Adjustable horizontal louvers are primarily used in conjunction with clear flat glass fenestrations. Consequently, the study was made on clear glass with approximately 80 per cent transmission. For the purposes of this study, the fenestration area was from wall to wall and from a three-foot sill height to the ceiling with horizontal louvers over the entire area.

4. *Interior Conditions* — Rooms having wall reflectances of 30 per cent and 70 per cent were studied with 30 per cent floor reflectance and 80 per cent ceiling reflectance. Readings were taken at five-foot intervals on a center line perpendicular to the fenestration and at a maximum, mid-point,

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 17-21, 1956, Boston, Mass. AUTHORS: Engineering Research, Southern Methodist University, Dallas, Texas; Research Engineer, Fenestra, Incorporated, Detroit, Mich.; and Research Department, Libbey-Owens-Ford Glass Co., Toledo, Ohio, respectively.

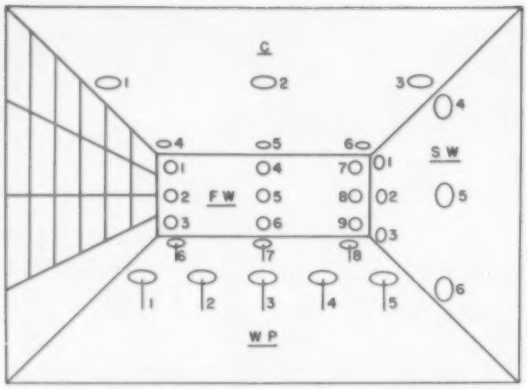

Figure 1. Location of cells in test model.

and minimum point five feet in from the front wall as shown in Fig. 1. (In this paper the walls perpendicular to the fenestration are designated as front and back walls.) Cosine and color corrected photocells having a scaled area of four square feet were used to simulate desks at a 30-inch work plane.

Testing Procedures

In developing a prediction technique for daylighting, it was necessary to take illumination tests under controlled conditions. Tests were taken on one-twelfth scale models using adjustable horizontal louvers as a control device. These tests consisted of sun tests, ground tests, and sky tests.

The sun tests were taken under an artificial sun condition. The room model was enclosed in a black vault with an artificial sun consisting of two floodlights focused on the plane of the fenestration at an angle of 30-degree altitude. For 45-degree and 60-degree altitude angles, the model was tilted forward at 15 degrees and 30 degrees respectively. To obtain azimuth conditions, other than normal to the fenestration, the model was rotated with respect to the incident rays of the artificial sun. This necessitated varying the intensity of one floodlight to produce uniform distribution across the fenestration area.

The ground tests were taken in the artificial sky used in previous tests. The artificial sky was adjusted to the uniform sky pattern and the model was inverted as previously for uniform ground conditions. A series of ground tests, using a strip similar to sidewalks or other concrete areas, was taken to determine the effect of location on the distribution of illumination within the room. As with previous ground surveys under sun conditions, higher levels of illumination at the interior side of the room on the work plane were obtained as the high reflecting ground surface approached a position equal to the sill height away from the fenestration wall. Naturally, this effect only applies for areas of equal intensity. Where the shadow effect is large as in the case of direct shading from the sun or an overcast sky, the optimum position may be further out from the fenestration.

The sky tests were obtained by subtracting uniform sky and ground tests. This technique was necessary due to low levels of illumination obtained from sky tests under the artificial sky at the laboratory since the intensities required for accurate measurements under the artificial sky on rooms with adjustable horizontal louver control were prohibitively large. Consequently, a uniform sky and ground vault was constructed for the combination sky and ground tests.

The same testing technique previously reported was used on the adjustable horizontal louver test.[1,2] The exterior tests shown in Table I were taken under natural conditions using the photographic recording technique. The test positions for the exterior tests are shown in Fig. 1. The cells on the work plane were at five-foot intervals, on a center line perpendicular to the fenestration, and on a line five feet in from the front wall. The locations on the ceiling and walls were two feet from intersecting planes and on center points as shown.

Performance Data

The illumination values shown in Table I were taken on the one-twelfth scale model under natural conditions. All of the tests were taken on a model room having a wall reflectance of 70 per cent, a ceiling reflectance of 80 per cent, and a floor reflectance of 30 per cent. The scaled room dimensions were 30 ft by 30 ft with a 12-foot ceiling height. The fenestration was from wall to wall and from a three-foot sill height to the ceiling. The fenestration was clear glass with simulated metal windows having a transmittance of 80 per cent, and horizontal louvers covering the entire fenestration area. The illumination values were recorded with photocells at the positions shown in Fig. 1.

All tests were taken with a ground of green grass having a reflectance of 8.5 per cent except test No. 11 where a 12-foot simulated concrete area having a reflectance of 50 per cent was placed immediately in front of the fenestration area. The tests were taken with the incident illumination values shown in the table and with the louvers adjusted at the angle shown (measured with the inside edge of the louver up from the horizontal).

TABLE I — Illumination values taken in a 30 x 30 x 12-foot test room with floor reflectance of 30%; ceiling (*C*) reflectance of 80%; a wall (*FW & SW*) reflectance of 70%; and a 30-inch work plane (*WP*). The fenestration is clear glass in metal windows extending from wall to wall with a 3-foot sill and horizontal louvers over the entire fenestration. On Test #10 the sun azimuth was 30° and 0° for the remainder.

Test	1	2	3	4	5	6	7	8	9	10	11
Inc. Illum. Sun & Sky	5405	5437	5277	6862	6612	6732	7446	7543	7522	5427	7560
Inc. Illum. Ground	520	510	531	421	425	423	314	272	293	425	664
Sun Alti.	60°	60°	60°	45°	45°	45°	30°	30°	30°	50°	30°
Louver	60°	45°	30°	60°	45°	30°	60°	45°	30°	45°	45°
WP-1	100.0	175.0	242.0	122.0	221.0	339.0	133.0	267.0	417.0	174.8	360.0
WP-2	72.0	135.0	182.5	80.0	164.0	245.0	97.0	188.0	292.0	132.0	261.0
WP-3	45.5	94.0	129.0	57.7	115.0	163.0	67.0	133.0	193.0	92.0	183.0
WP-4	33.3	69.0	98.0	40.6	83.0	123.0	47.8	102.5	150.0	68.0	137.5
WP-5	26.5	57.9	82.0	34.2	70.0	107.0	39.5	89.0	133.0	57.0	115.0
WP-6	93.0	172.0	245.0	115.0	212.0	320.0	127.0	246.0	398.0	167.0	338.0
WP-7	44.1	87.6	125.0	55.1	108.0	158.0	63.0	129.0	188.0	87.5	172.0
WP-8	24.0	52.0	77.0	30.2	65.0	100.0	36.5	82.5	123.0	52.0	103.0
FW-1	182.0	273.0	343.0	210.0	332.0	452.0	218.0	390.0	539.0	265.0	514.0
FW-2	136.0	232.0	315.0	165.0	277.0	408.0	176.0	323.0	462.0	226.0	442.0
FW-3	52.0	97.0	133.0	64.0	117.0	180.0	72.0	156.0	220.0	95.0	186.0
FW-4	42.3	92.0	122.0	54.0	108.0	146.0	63.0	132.0	165.0	89.0	168.0
FW-5	38.2	82.0	117.0	48.3	100.0	140.0	56.4	125.0	177.0	80.0	158.0
FW-6	32.0	68.0	103.0	39.9	85.0	137.0	47.2	107.5	163.0	67.0	138.0
FW-7	22.8	50.8	68.0	29.9	63.0	90.0	35.6	79.0	108.0	49.3	95.0
FW-8	22.9	53.1	77.0	30.5	80.0	102.0	35.4	70.0	123.0	50.0	102.0
FW-9	19.6	43.5	68.0	25.6	55.0	93.0	30.4	73.0	112.0	43.5	88.0
SW-1	30.5	70.0	93.0	40.1	86.0	122.0	47.3	117.0	154.0	68.0	136.0
SW-2	30.6	75.0	111.0	40.5	94.0	147.0	48.0	122.0	184.0	70.1	145.0
SW-3	28.2	67.0	105.0	36.2	82.0	140.0	45.1	105.0	174.0	63.0	126.0
SW-4	36.1	86.0	115.0	47.1	105.0	147.0	57.4	137.5	185.0	83.0	163.0
SW-5	35.8	88.0	129.0	47.3	112.5	171.0	56.8	142.5	217.0	87.0	170.0
SW-6	30.0	75.0	122.0	39.0	94.0	156.0	46.2	122.0	197.0	73.0	145.0
C-1	271.0	364.0	388.0	314.0	422.0	495.0	309.0	492.0	684.5	350.0	718.3
C-2	32.8	70.0	83.0	41.5	87.0	104.0	47.3	95.0	118.0	67.0	147.0
C-3	19.1	42.2	58.2	25.0	51.9	76.0	29.6	67.0	91.0	42.0	88.0
C-4	235.0	310.0	365.0	252.0	367.0	471.0	257.0	425.0	589.0	293.0	591.0
C-5	29.6	59.8	77.0	37.0	71.0	92.0	42.0	83.0	110.0	58.0	118.0
C-6	16.8	38.0	52.0	22.5	46.0	67.0	24.2	52.0	82.0	36.8	73.0

All tests were taken under a clear sky for the sun altitudes given in the table.

The performance data taken under the artificial conditions has been reduced to coefficients of utilization given in Tables II through VII.

Prediction Technique

In developing illumination coefficient curves, it was found that many more curves would be required than in the previous papers due to the variation in the sun angles, sun altitudes, and louver adjustments. Consequently, for simplicity and brevity; the authors have adopted tables of coefficients of utilization rather than curves as reported in previous papers.[1,2]

This prediction technique eliminates the necessity of solving the numerous variables employed in the previous technique. The tables use the physical dimension of the room, the wall reflectances, the sun altitudes, and the louver adjustments as variables. The values in the tables have been empirically determined from over 600 tests and are given for the maximum point, the mid-point, and a minimum point located on a center line of the room perpendicular to the fenestration area at a 30-inch work plane height. The maximum point is considered five feet in from the fenestration, the mid-point at the center of the room, and the minimum point five feet in from the wall opposite the fenestration area. The values are based on rectangular rooms varying in length and width from 20 to 40 feet in 10-foot modules. Values for both 30 per cent and 70 per cent wall reflectances with 30 per cent floor reflectance and 80 per cent ceiling reflectance are given in the tables. Straight line interpolation can be used for values lying between those given in the tables.

To predict the daylight illumination distribution in a room with adjustable horizontal louvers as a sun control, values of illumination on the work plane at the maximum, mid-point, and minimum point of the room are computed for each point using the following equation:

$$E = E_i \times A_W \times K_B \times K_C \times K_{L\text{-}W} \times T_W \times M.F.$$

where

E = Illumination on the work plane from the source in footcandles

E_i = Illumination incident on the vertical plane of the fenestration from the source in footcandles

TABLE II—Coefficients of utilization based on horizontal louver adjustment with sun and sky as source. (K_B)

	Wall Refl.	30° V. B. 70%	30° V. B. 30%	45° V. B. 70%	45° V. B. 30%	60° V. B. 70%	60° V. B. 30%
30° SUN	Max	.0630	.050	.0394	.0312	.0208	.0156
	Mid	.0462	.0324	.0337	.0216	.0176	.0110
	Min	.0342	.0204	.0250	.0143	.0130	.0071
45° SUN	Max	.0553	.0434	.0345	.0274	.0198	.0141
	Mid	.0416	.0301	.0304	.0211	.0158	.0105
	Min	.0308	.0182	.0225	.0127	.0117	.0064
60° SUN	Max	.0464	.0362	.0313	.0236	.0190	.0135
	Mid	.0370	.0264	.0270	.0185	.0140	.0092
	Min	.0274	.0159	.0199	.0111	.0104	.0056

TABLE IV—Coefficients of utilization based on length and with of room with sun and sky as source. ($K_{L\text{-}W}$)

Wall Refl.	Length	20′ Width 70%	20′ Width 30%	30′ Width 70%	30′ Width 30%	40′ Width 70%	40′ Width 30%
MAX	20′	.0500	.0500	.0470	.0480	.0455	.0475
	30′	.0353	.0357	.0330	.0350	.0323	.0343
	40′	.0268	.0285	.0250	.0280	.0243	.0275
MID	20′	.0500	.0500	.0335	.0305	.0195	.0190
	30′	.0376	.0370	.0250	.0257	.0173	.0167
	40′	.0288	.0328	.0198	.0230	.0125	.0148
MIN	20′	.0500	.0500	.0265	.0210	.0125	.0099
	30′	.0380	.0410	.0200	.0183	.0120	.0097
	40′	.0288	.0368	.0170	.0175	.0108	.0090

A_W = Area of the masonry opening for the window in square feet

K_B = Illumination coefficient for adjustable horizontal louvers (Tables II and V)

K_C = Illumination coefficient of the ceiling height (Tables III and VI)

$K_{L\text{-}W}$ = Illumination coefficient for the length and width of the room (Tables IV and VII)

T_W = Ratio of clear window opening to masonry opening (.8 for typical metal window construction)

$M.F.$ = Maintenance Factor

The transmission factor of clear glass (80 per cent) has been included in the coefficient since louvers are usually used in conjunction with clear flat glass. Where computations are to be made on glass other than 80 transmission, a ratio of the transmission factors must be included in the equation. Two computations using the above formula must be made, one for that portion using the sun and sky as a source and one for that portion using the ground as a source.

The predictions for illumination from the sun and sky have been combined in one set of tables. It is difficult to separate the illumination from the sun and sky because the sky area immediately surrounding the sun is generally much brighter than the remainder of the sky. For this reason, more accurate results can be obtained by combining the effect of the sun and sky together.

TABLE III—Coefficients of utilization based on ceiling heights with sun and sky as source. (K_C)

Clg. Ht. / Wall Refl.		8′ 70%	8′ 30%	10′ 70%	10′ 30%	12′ 70%	12′ 30%	14′ 70%	14′ 30%
MAX		.154	.170	.129	.131	.107	.112	.091	.091
	Width								
MID	20′	.100	.106	.101	.106	.099	.102	.091	.091
	30′	.074	.080	.086	.090	.091	.093	.091	.091
	40′	.070	.074	.079	.084	.088	.091	.091	.091
MIN	20′	.080	.080	.091	.091	.093	.093	.091	.091
	30′	.068	.068	.079	.079	.087	.087	.091	.091
	40′	.064	.064	.076	.076	.084	.084	.091	.091

TABLE V—Coefficients of utilization based on horizontal louver adjustment with uniform ground as source. (K_B)

Wall Refl.	30° V. B. 70%	30° V. B. 30%	45° V. B. 70%	45° V. B. 30%	60° V. B. 70%	60° V. B. 30%
MAX	.150	.108	.141	.102	.087	.063
MID	.141	.094	.118	.077	.067	.048
MIN	.124	.072	.096	.056	.049	.028

TABLE VI—Coefficients of utilization based on ceiling heights with uniform ground as source. (K_C)

Clg. Ht. / Wall Refl.		8′ 70%	8′ 30%	10′ 70%	10′ 30%	12′ 70%	12′ 30%	14′ 70%	14′ 30%
MAX		.174	.200	.142	.157	.117	.123	.091	.091
	Width								
MID	20′	.104	.116	.110	.121	.106	.112	.091	.091
	30′	.074	.082	.092	.099	.099	.106	.091	.091
	40′	.058	.062	.079	.083	.092	.096	.091	.091
MIN	20′	.078	.082	.093	.097	.099	.102	.091	.091
	30′	.058	.060	.074	.076	.090	.092	.091	.091
	40′	.052	.056	.070	.071	.086	.087	.091	.091

TABLE VII—Coefficients of utilization based on length and width of room with uniform ground as source. ($K_{L\text{-}W}$)

Wall Refl.	Length	20′ Width 70%	20′ Width 30%	30′ Width 70%	30′ Width 30%	40′ Width 70%	40′ Width 30%
MAX	20′	.0500	.0500	.0475	.0485	.0455	.0490
	30′	.0353	.0383	.0333	.0390	.0323	.0383
	40′	.0273	.0313	.0260	.0303	.0250	.0310
MID	20′	.0500	.0500	.0330	.0320	.0215	.0210
	30′	.0373	.0413	.0247	.0277	.0173	.0200
	40′	.0288	.0343	.0195	.0243	.0138	.0163
MIN	20′	.0500	.0500	.0235	.0205	.0115	.0097
	30′	.0387	.0437	.0193	.0190	.0107	.0096
	40′	.0295	.0358	.0153	.0173	.0088	.0087

The variation in illumination due to the distance of the observation point from the fenestration has been included in the coefficient of length and width. This has eliminated using the distance in computing the illumination at a particular point. Since the variation due to ceiling height is affected by the room width, the K_C factor includes both ceiling height and room width.

After the illumination values for the maximum,

mid point, and minimum point have been computed for both the sun and sky source and the ground source, the respective values are added together and a footcandle curve may be drawn similar to that in previous papers.[1,2] By using the footcandle distribution curve, this technique can be applied to multilateral lighting as well as unilateral lighting.

Example

Predict the work plane illumination values for a 30 ft x 30 ft x 12 ft room with a main window 30 feet long and extending from a 36-inch sill to the ceiling with venetian blinds adjusted at 45 degrees and covering the entire fenestration area. The room reflectances are 30 per cent for the floor, 70 per cent for the walls, and 80 per cent for the ceiling. The incident illumination is 7,037 footcandles from a clear sky with the sun incident on the fenestration area at 0-degree azimuth and 45-degree altitude. These are the conditions of Test No. 5 in Table I with 94 per cent of the incident illumination from the sun and sky, and six per cent from the ground.

Step 1

Determine the variables in the equation

$$E = E_i \times A_W \times K_B \times K_C \times K_{L\text{-}W} \times T_W \times M.F.$$

$E_{iS} = 6612$ footcandles from sun and sky

$E_{iG} = 425$ footcandles from ground

$A_W = 30 \times 9 = 270$ square feet

$T_W = .8$

$M.F. = 1$

Step 2

Determine the coefficients of utilization for the for the blinds for the maximum, mid, and minimum points from the sun and sky.

K_B Max = .0345 from Table II
Mid = .0304 from Table II
Min = .0225 from Table II

Step 3

Determine the coefficients of utilization for the ceiling height for the maximum, mid, and minimum points from the sun and sky.

K_C Max = .107 from Table III
Mid = .091 from Table III
Min = .087 from Table III

Step 4

Determine the coefficients of utilization for the length and width for the maximum, mid, and minimum points from the sun and sky.

$K_{L\text{-}W}$ Max = .0330 from Table IV
Mid = .0250 from Table IV
Min = .0200 from Table IV

Step 5

Determine the coefficients of utilization for the blinds for the maximum, mid, and minimum points from a uniform ground.

K_B Max = .141 from Table V
Mid = .118 from Table V
Min = .096 from Table V

Step 6

Determine the coefficients of utilization for the ceiling height for the maximum, mid, and minimum points from a uniform ground.

K_C Max = .117 from Table VI
Mid = .099 from Table VI
Min = .090 from Table VI

Step 7

Determine the coefficients of utilization for the length and width for the maximum, mid, and minimum points from a uniform ground.

$K_{L\text{-}W}$ Max = .0333 from Table VII
Mid = .0247 from Table VII
Min = .0193 from Table VII

Step 8

Compute the illumination for the maximum, mid, and minimum point for the sun and sky as a source.

$E_{Max} = 6612 \times 270 \times .0345 \times .107 \times .0330 \times .8 \times 1$
$= 174$ footcandles

$E_{Mid} = 6612 \times 270 \times .030 \times .091 \times .0250 \times .8 \times 1$
$= 97$ footcandles

$E_{Min} = 6612 \times 270 \times .0225 \times .087 \times .0200 \times .8 \times 1$
$= 56$ footcandles

Step 9

Compute the illumination for the maximum, mid, and minimum point for the uniform ground as a source.

$E_{Max} = 425 \times 270 \times .141 \times .117 \times .0333 \times .8 \times 1$
$= 50$ footcandles

$E_{Mid} = 425 \times 270 \times .118 \times .099 \times .0247 \times .8 \times 1$
$= 26$ footcandles

$E_{Min} = 425 \times 270 \times .096 \times .090 \times .0193 \times .8 \times 1$
$= 15$ footcandles

Step 10

Compute the total illumination at each point for the sun, sky, and ground by adding the values in Step 8 and 9.

$E_{Max} = 174 + 50 = 224$ footcandles

$E_{Mid} = 97 + 26 = 123$ footcandles

$E_{Min} = 56 + 15 = 71$ footcandles

This compares with the measured results of

$E_{Max} = 221$ footcandles

$E_{Mid} = 115$ footcandles

$E_{Min} = 70$ footcandles

Conclusions

1. This is a practical method for predicting the work plane distribution of daylight through clear glass fenestration using adjustable horizontal louvers as a sun control.

2. Since the coefficient of utilization for horizontal louvers is considerably higher for light reflected from the ground, much consideration should be given to the proper design of exterior terrain. The light reflected from the ground is frequently the major source of illumination where horizontal louvers are used to control sky brightness with no sun on the fenestration.

3. This study demonstrates that sunlight through clear glass fenestration controlled by adjustable horizontal louvers provides a high quality of light on the working plane because:

a. Direct glare is eliminated when louvers are properly adjusted.

b. Direct sunlight is reflected to the interior of the room.

c. Good distribution of light is obtained.

4. Obviously, the quantity of illumination is ample.

5. The authors believe that the use of tables of coefficients of utilization greatly simplifies the prediction techniques developed by them in the past.

References

1. Griffith, J. W., Arner, W. J., and Conover, E. W.: "A Modified Lumen Method of Daylighting Design," ILLUMINATING ENGINEERING, Vol. L, No. 3 (March 1955).
2. Griffith, J. W., Arner, W. J., and Conover, E. W.: "Daylighting Design With Overhangs," ILLUMINATING ENGINEERING, Vol. LI, No. 3 (March 1956).

DISCUSSION

DOMINA EBERLE SPENCER:* The data given in this paper may be analyzed in two ways: as the basis for a technique of calculation or as a source of quantitative information on the distribution of light in rooms employing venetian blinds.

As a method of calculating the distribution of light produced with adjustable horizontal louvers, this paper may be compared to Ward Harrison's important paper of 1916 which laid the foundation for the use of coefficients of utilization in artificial lighting. Like that paper, we have here a method which is frankly empirical and which is confined to obtaining the quantity of light incident on the desks. This is a good first step but is not the final result that is needed, for it gives no information on the distribution of light on walls and ceilings and does not apply to all room shapes.

Various questions may be asked concerning the accuracy of the present measurements. For example, the light produced by twin spotlights does not give an incident distribution equivalent to that from the sun. Has the magnitude of this possible discrepancy been analyzed? How accurately may the artificial sky be considered equivalent to any natural sky?

Can the entire effect of room shape be incorporated into a single factor by expressing the data in terms of domance (index of room proportion), k_r, as was shown possible in a previous study[1] of daylighting? Is any information available on the amount by which venetian blinds in a horizontal position reduce the quantity of light on the desks?

To make a complete analysis of the problem at hand and to place it on a firm theoretical foundation, two sets of experimental data are needed: (a) the brightness of the blinds as viewed from eye level, when they are tilted so as to deflect sunlight to the ceiling, (b) the quantity of light incident on ceiling and floor *without interflections*. Could a further study make available these two basic pieces of information? If this were possible, the interflection method could be extended to this problem, thus permitting a complete theoretical analysis of quantity and quality in any room which received its lighting from a window wall with adjustable horizontal louvers.

In themselves, the data given in Table I are of great interest. They show that for the cases measured, the quantity of light incident on the desks varies by a factor of 3 or 4. The maximum adaptation ratio for any of the parts of the room measured is between 5 and 11. Thus, the daylight distribution is close to satisfying the 3:1 adaptation criterion. A question which would make a suitable topic for a paper at a coming conference would be how to combine these daylighted interiors with supplementary artificial lighting in such a way that the criteria for optimum luminous environments are satisfied for all lines of sight.

In view of the importance of schoolroom lighting and the volume of present school construction, work on the best method of combining daylighting and artificial lighting to provide optimum visual conditions at all times is urgently needed. One method which would certainly satisfy these criteria is the combination of venetian blinds on a single window wall with a luminous ceiling, designed so that only a strip at the back of the room would be used in good weather, but so that the entire ceiling could be lighted on dark days. The optimum design of such a system and its performance under all weather conditions would make a fruitful subject for further study.

1. Spencer, D. E., and Stakutis, V. J.: "The Integral-Equation Solution of the Daylighting Problem," *Journal of the Franklin Institute*, 252, p. 225-237 (September 1951).

R. W. MCKINLEY:* The authors present an interesting and useful new technique which I hope will be widely applied. Because it seems ready for immediate application I would like the authors to give us some application guidance. The sort of thing that the engineer and architect should have in mind will be suggested by the following questions:

(1) What magnitude of error must be expected if metal slat venetian blinds or diminutive louver shade screens are used?

(2) Does the 80 per cent transmittance value apply to the glass only or to the glass-sash combination?

(3) I believe that there is an implication in the calculated test data that sun and sky contribute 90-95 per cent of the illumination on a vertical fenestration and that 5-10 per cent is added by ground reflection. Is it safe to assume that this is a reasonable rule of thumb?

(4) Have the authors any suggestions regarding the selection or use of slat shades? For example: What dimensions, color and setting of slats would they suggest to be considered first, when perhaps one does not have time to

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make a completely detailed study? What may the owner of an existing installation read from this paper? What can it suggest to him in the way of best utilizing his equipment?

I would like to comment on the excellent character of the slides themselves. You can see them, and read them clearly. That is so rare an experience that I think it is worthy of note.

HEMPSTEAD BULL:* It is evident from the sample calculation of workplane illumination that reflected flux from the ground is an important component, particularly with respect to illumination at stations remote from the window. It is also evident from Table I that the percentage of total flux which is contributed by ground reflection varies over a considerable range and is a function of sun altitude. It would be of interest if test data are available showing the ratio of ground flux to total flux as a function of sun altitude.

FOSTER K. SAMPSON:** We on the west coast have probably had more experience with actual applications of horizontal louvers than people of any other area. The only satisfactory installations are those which block all direct vision of the sky from within the room. The paper reports on louvers set at 30, 45 and 60 degrees with the width of the louver 1.25 times the spacing between blades. At 30 degrees this leaves an angle of 19 degrees between the bottom of one blade and the top of the next lower blade through which the room occupants can see the sky. At the 45-degree setting the corresponding angle is 8 degrees. The sky seen through blades set in these ways is usually glaring and distracting.

A 70 per cent reflection factor paint will create uncomfortably high brightness when the blades are in direct sunlight. At least the lower, or undersides of the louvers should be painted dark enough to create an average brightness over the fenestration pattern of not to exceed ten times task brightness. The finished surface should have matte characteristics so as not to provide high specular reflection.

This paper is well done and the information should be of considerable value to anyone working on problems of this nature.

R. A. BOYD:† It seems to me that the authors have presented a method of predicting the daylighting of a room, fenestrated with clear flat glass and adjustable horizontal louvers, suitable for use in building design. I have applied the method to several room arrangements on which we have daylighting data and find the agreement to be within 15 per cent, even though small differences existed in louver, floor and ceiling reflectances. The method is easy to apply and yet takes into account a number of different room conditions.

Personally, I would like to see this method expanded to include a greater range of room surface reflectances. If this range were to include minimum reflectance for all surfaces then the amount of scattered light at each station could be calculated and an estimate made of the surround brightness. Also, for a consideration of the quality of the daylighting it is highly desirable to be able to calculate the louver brightness for several different observer positions.

CARL J. ALLEN:†† The authors are to be congratulated for providing the lighting art with this simple-to-understand and easy-to-use method of predicting daylighting results with horizontal louvers. In my work with the school administrators and designers I find that venetian blinds are very well liked in those areas where there is an abundance of daylight and the atmosphere is relatively clean. The Florida schools are good examples of this. Recent developments in venetian blind design, both of the metal and wood types, now permit a full closure type blind. Such a blind gives good daylight control and also adequate dimout for audio-visual projection.

While this comment certainly does not detract from the merits of the paper, I would like to know what type of light meter one uses to measure footcandles to four significant figures as in Table I for the incident illumination for sun and sky.

H. F. KINGSBURY:** The authors are to be thanked for reducing to simple practice the prediction of daylighting through clear glass, which has now been extended to include horizontal slat type shades.

Two points, however, disturb me somewhat. In the authors' example, the calculations agree, at the front and rear of the room, within 1½ per cent with the experimental values. Is this order of accuracy to be expected in other experimental checks of calculation accuracy? It would be helpful if the authors could assign some limits of error to be expected, if the data to determine this area are available.

Secondly, if this order of accuracy is to be expected, some simplifications of the technique would seem practical, naturally with some sacrifice of accuracy. Certainly, ±10 or 20 per cent errors should appear reasonable. The reason for suggesting such a possible modification is that people in general are lazy, and the easier any computation method is, the more widespread will be its potential usage. Such widespread usage should be the aim of almost any daylight distribution computation, since there are actually very few buildings designed that have employed any more than crude "rules of thumb" in daylighting design, and many consequent mistakes or uneconomic decisions are made.

Another point that might be of further engineering assistance is to establish, if possible, the correlation between these daylighting measurements and the work done at the ASHAE Laboratories some time ago on solar heat gain. Have the authors checked this point and, if so, the results should be interesting.

J. W. GRIFFITH, E. W. CONOVER and W. J. ARNER:† In general, the authors agree with the various comments and suggestions brought out in the discussion.

In answer to Dr. Spencer's question regarding the accuracy of twin spotlights to simulate sunlight, it is difficult to establish the exact discrepancy between the distribution from the artificial sun and that of true sunlight. However, due to the large area of brightness immediately surrounding the sun, it is felt that the discrepancy will be insignificant in the final result. Thus far the results obtained in predictions based on the artificial sun tests have given results within 10 per cent of measured values under natural conditions for all three positions predicted. The effect of the room shape has not been reduced into a single factor, and information regarding the distribution of venetian blinds in a horizontal position is not available. The information to obtain the brightness of the blinds under varying condi-

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†Authors.

tions as well as the quantity of light incident on the ceiling and floor without interreflection could be obtained if financial assistance were available.

In answer to Mr. McKinley's question, the authors believe the magnitude of error, if applied to metal slat venetian blinds, would be well within the 10 per cent accuracy experienced thus far. The technique is not applicable to louver shade screens in present use today. The 80 per cent transmittance referred to as T_w applies to the ratio of clear window openings to masonry openings in this paper. An 80 per cent transmittance of light from 180 degrees for clear glass has been included in the tables, and where glass other than 80 per cent is used a ratio of the two transmission factors must be included in the computations. The authors did not intend to imply that the added illumination from the ground reflection is in the order of from 5 to 10 per cent. In the particular cases shown in Table I, the magnitude of illumination from the ground was low due to a reflection factor of 8½ per cent for green grass. For conditions where sun is not incident on the fenestration, the major portion of the incident illumination on the fenestration may be from below the horizon. The illumination on a vertical fenestration from the ground varies considerably, as pointed out by Dr. Bull in his discussion. Due to the dynamic quality of daylighting, the authors have refrained from making specific suggestions regarding the use of horizontal louver controls. The technique presented in this paper is applicable to a wide range of conditions, and it is believed that a study of alternate designs must be conducted to obtain the best combination for daylighting of interiors. It is believed that a detailed study requiring a few hours is far more satisfactory than adopting a rule-of-thumb attitude toward daylighting design. Further suggestions as to the use and application of horizontal louvers have been brought out by Mr. Sampson and Mr. Allen.

Simplification of the prediction technique similar to Mr. Kingsbury's suggestion is under study and should be available in the near future. Thus far correlation between the daylighting measurements and the work done at the ASHAE laboratories has not been complete. A cosine and color-corrected photocell with a neutral density filter and a 0-20 microammeter was used to measure the incident illumination on natural tests. The four figures were obtained in calibration and should have been rounded off.

Industrial Lighting with 800 Milliamps

Mufflers for automobiles are manufactured in this area at the Gladstone Plant of Arvin Industries Inc., Columbus, Ind. A total of 300 industrial fixtures, using 96-inch rapid start 800 ma lamps, are mounted 12 feet above the floor in staggered rows. Units are spaced at 20 feet and rows at 8 feet. Illumination levels are from 50 to 60 footcandles at working height of 2½ to 3½ feet above the floor. Layout by Public Service Co., Columbus, Ind. Photo and data from Charles R. Thomas, Benjamin Electric Manufacturing Co., Des Plaines, Ill.

Cincinnati's skyline is dominated by this floodlighting job using . . .

Combination Mercury and Incandescent

George H. Seiter
Ohio Valley Section
Great Lakes Region

MODERN floodlighting installations frequently meet with problems not encountered a few years ago. High level streetlighting, for example, is often so designed that building facades are also lighted to high levels. Famous old landmarks are now surrounded by new skyscrapers. Effective beaming in downtown areas is frequently a problem. In planning the floodlighting of the Cincinnati Gas and Electric Company building, the engineers had to include in their calculations the city's modern high-intensity streetlighting which provides some four footcandles on the streets and an average of 30 footcandles on the fronts of buildings.

To create a really distinctive downtown land-

Mr. Seiter, who designed this floodlighting installation, is with Cincinnati Gas and Electric Co. The installation won first prize in the Ohio Valley Section's contest for My Most Interesting Lighting Job and in the Great Lakes Regional contest, and was a runner-up in the National contest.

mark, visible from all of Cincinnati's seven hills and from the bridges which span the Ohio, colored floodlighting has been designed to brilliant intensity on the upper portion of the building only. Extending from the thirteenth floor set-back, to the copper roof of the 18-story building, the jewel-like colors of the installation not only set the building apart from its fellows but also identify the city itself for commercial airlines.

Two 400-watt high intensity E-H1 mercury vapor floodlights (not color-corrected) overhang each side of the tower to illuminate the roof. At the same time these bluish sources develop an interesting blue color on the copper roof. On each side of the 15th floor set-back, rows of twelve 500-watt clear floodlights in wide beam floodlights provide the proper intensity to give the building form. At the 13th floor corner set-backs, huge urns which form part of the architectural design conceal four 500-watt amber floodlights at each corner. In addition twelve 500-watt amber floodlights surround each of the four urns. Amber floods were used at this point as a complementary color to the blue roof and to the identify the corners of the building. The installation required a total of eight E-H1 mercury vapor lamps, 48 clear and 64 amber colored floodlights. There is an average of 40 maintained footcandles on the lighted portion of the building.

Servicing of the mercury floodlights overhanging the roof is accomplished by men inside the building. Special brackets were designed so the floodlights could be moved inside the building through removable panels in the cupola for re-lamping, cleaning and maintenance. The other units are readily accessible to electricians from the 13th and 15th floors where they can be maintained with complete safety.

Focusing Technique

When the installation was complete, the real question was how to focus the units. The logical place to view and appraise the focusing of floodlights is from the roofs of buildings about a square away. Shouting at night from this distance would bring riot squads, hand signals could not be seen, and flashlight signals were too easily missed or misinterpreted. Walkie-talkies were used for communicating from observation points in four distant buildings, one facing each side of the floodlighted building. This unusual method of adjusting the floodlights permitted pin-point precision to provide even distribution throughout the installation. Such precision was especially valuable in adjusting the amber units since the color had to be controlled to bring out the architectural lines of the building. An additional advantage in using walkie-talkies was completing the entire job of focusing the floodlights in one evening.

The installation has created further interest in floodlighting other buildings in the area. Several firms are studying the possibilities of installations for their buildings. Many older installations have plans in progress for modernization.

Index to 1956— Officer-Committee Directory

The Personnel section of the Index to 1956, mailed with the January 1957 issue of ILLUMINATING ENGINEERING, this year gives the business addresses, when available, of I.E.S. officers and committee personnel for 1955-1956 and 1956-1957. This section can be used as a Directory of I.E.S. officers and committee members. Hold on to your copy.

Measurements in Daylighted Classrooms in Arizona

By J. R. WILLIAMS

ARIZONA, like the rest of the United States, has had a tremendous increase in school construction since World War II. And like the rest of the country, these schools in Arizona have employed radical new designs, as compared to the Pre-World War II school, to give maximum utilization of space and equipment. In the past few years many have studied and reported on different phases of these modern schools with special emphasis on heating, air-conditioning, classroom equipment and lighting, both artificial and natural. Since a great effort has been made to design fenestration so as to take advantage of natural light, numerous studies have been made in the field and with test models to see if the designer is accomplishing the desired results.

Many believe that information from the Southwest on the results of classroom daylighting is needed from actual working examples since this section of the country has an extremely high percentage of clear days throughout the year.[1] Also, this high percentage of clear days has encouraged schoolroom designers in this area to try to take full advantage of this daylight in their fenestration design.

Sunshine in the Salt River Valley area of Arizona, as reported by the United States Department of Commerce's Weather Bureau, averages 85 per cent of the possible amount for the year — an unusually high normal, comparatively speaking. During the winter there are, on the average, only six or seven cloudy days per month, but the remainder of the time the skies are sunny and daytime temperatures mild. In Spring, sunshine is at its best, shining between 80 and 90 per cent of the daylight hours during the three months of March, April and May.[2]

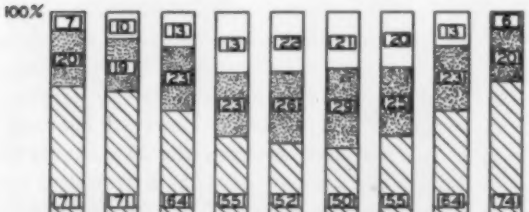


Figure 1. U. S. Department of Commerce, Local climatological data, Phoenix, Arizona.

Fig. 1 shows the average percentage of clear days, partial cloudy days and total cloudy days for the past 60 years. Since partial cloudy days only include up to 0.5 sky coverage, these days can be considered sunny.

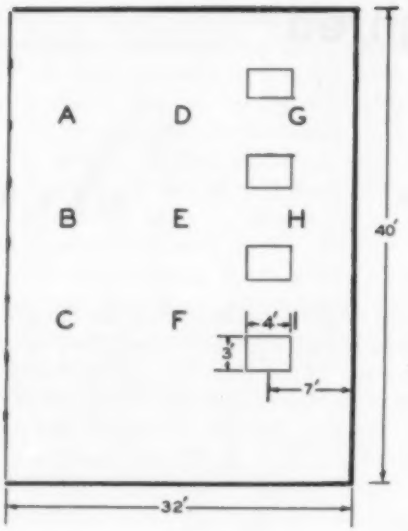
Procedure

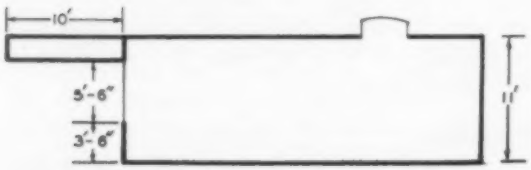
In order to determine how much daylight illumination is provided with the fenestration in this sunny area, four Post-World War II classrooms in different schools in separated localities in the Salt River Valley area of Arizona were selected for survey. Each of the four schools is typical of the present construction in Arizona. In each test room, teachers were furnished with a light meter and classmates formed teams to measure the footcandle levels in nine locations in that room every hour that classes were in session. The nine test stations for survey in the four classrooms were located as shown by the alphabetical letters in Fig. 2. This survey was carried on for 45 school days in the months of January, February and March 1956. Of the 15,000 readings that were taken, a very small fraction of one per cent of the total were discarded because of obvious inaccuracies. General Electric Co. meters, color-corrected and cosine-corrected, were used by the students.

All brightness readings were taken at noon in the latter part of March on completely clear days, using a Spectra Brightness Spot Meter. Interior brightness readings were made from a seated position in the center of the rear of the room.

An average was calculated for the footcandle

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 17-21, 1956, Boston, Mass. AUTHOR: Arizona Public Service Co., Phoenix, Ariz.





Washington High School

Figure 2. Plan view and sectional view. Clear glass in window. No louvers or diffusing surface below plastic dome.

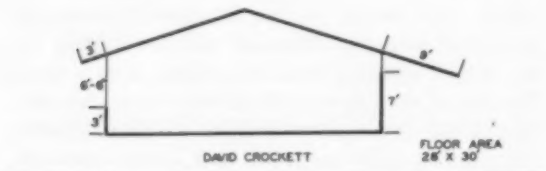


Figure 3. Sectional view. Floor plans identical.

readings in respect to identical hours and room positions for each day of the test period. With this information, curves for each position could be drawn with footcandles as ordinates and time (hours) as abscissas.

Description of Classrooms

Footcandle distribution in the test rooms was not measured at identical locations because of seating arrangements although three of the four rooms are the same size.

Figs. 2 and 3 show simple views of these classrooms. Three of the rooms are 28 by 30 feet and are similar in window wall and clerestory location with the major difference in construction being in their roof overhangs. Of the four classrooms, only Washington High School uses the sky dome for bringing daylight into the side of the room away from the window wall, instead of using a clerestory or monitor.[3]

All classrooms selected had the window wall facing north, which is typical of the majority of classrooms in Arizona.

Results

It is a tribute to the American boy and girl in the way these student teams performed this task. The cooperation given by superintendents, principals, teachers and students was proof that they are cognizant of the importance that lighting has in their work.

By plotting the footcandle averages versus time, it was possible to draw smooth curves for each position, giving an easily deciphered curve. It is of interest that the most distant point from any of the resultant curves was five footcandles and the most points off from any one curve was two.

From the curves for each classroom, the window side (A, B, C), the middle of the room (D, E, F), and the opposite side from the window (G, H, I), footcandle values can easily be determined.

It should be stated strongly that these data should not be used to compare one classroom with the other, whether it be footcandle level, fenestration design, or brightnesses.[1] However, one comparison can be made between the two curves of Washington High School since the survey data for each curve were taken from the same room. At Washington High School it was possible to block out the sky domes completely with heavy shades to measure footcandle distribution with sky domes and without sky domes at the same time.

Conclusions

Although a great majority of the combined readings for these classrooms are above the American

Figure 4. Exterior view of large window of survey classroom.

Figure 5. Exterior view of monitor side.

Figure 6. Brightnesses in footlamberts. All brightness measurements were taken for each classroom at noon in the latter part of March, 1956.

Figure 7. Brightnesses in footlamberts.

Clarendon School

Figures 4, 5, 6, 7, 8.
Clear glass in window and monitor.
No shades at window.
Ceiling: white acoustical tile.
Walls: stain wood and buff brick.
Floor: light tan and brown asphalt tile.
Reflectances: desks, 50%; ceiling, 85%; floor, 17%; front wall, 80%; chalkboard, 40%; brick, 20%.
Area outside window wall: lawn at floor level extending 100 feet to concrete sidewalk and asphalt paved street. No trees or shrubs high enough to shade window.
Combined readings of the nine test locations — per cent of total readings: over 100 ft-c, 0%; 51 to 100 ft-c, 51%; 31 to 50 ft-c, 47%; 0 to 30 ft-c, 2%.

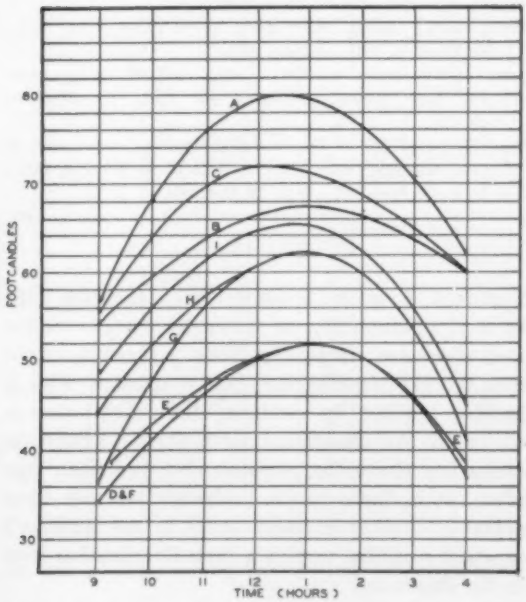
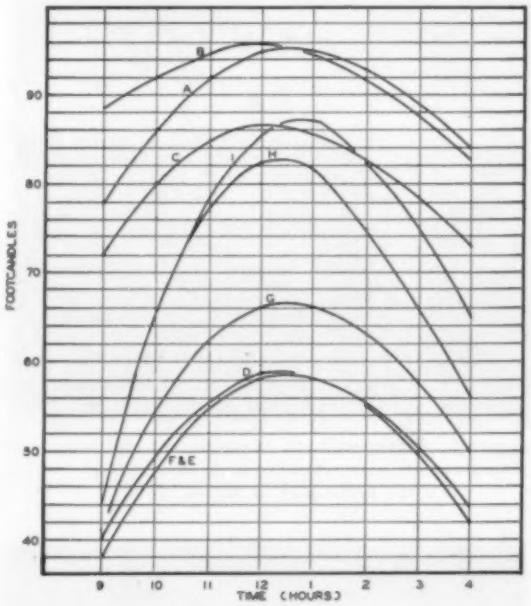


Figure 8. Averaged footcandle distribution for test period.

Figure 9. Brightnesses in footlamberts.

Figure 10. Test room. Brightnesses in footlamberts. Curtains on monitor for visual-aid instruction only.

Figure 11. (right) Letters A, B, C represent desk next to window wall. D, E, F: center row of desks. G, H, I: desks next to monitor wall.



David Crockett School

Figures 9, 10, 11.

Figures 4 and 5 of Clarendon School are typical of David Crockett School since construction for fenestration and overhang is identical.

Clear glass in window and monitor.

No permanent shades at windows. (Blackout curtain for visual aid at window and monitor.)

Ceiling: white acoustical tile.

Walls: stain wood and red brick.

Floor: light tan and brown asphalt tile.

Reflectances: desks, 50%; floor, 15%; front wall, 75%; chalkboard, 40%; ceiling, 80%.

Area outside large window: playground of sparse grass and bare ground extending 200 feet. No trees or shrubs.

Combined readings of the nine test locations — per cent of total readings: over 100 ft-c, 3%; 51 to 100 ft-c, 74%; 31 to 50 ft-c, 22%; 0 to 30 ft-c, 1%.

Standard Practice recommended minimum, the level of illumination, as shown by the curves for each classroom, varies significantly throughout the day, thereby contributing little to quality. This is further verified by studying the brightnesses — where in the classrooms most of the brightness ratios are above the recommended practices,[4] too often, as in these rooms, designers overlook these points of quality in their desire to use Arizona's constant sunshine to give a high illumination level in the classroom.

There are things which can be said in favor of the daylighting methods used. The higher illumination levels have to some extent improved the general visibility and have added a cheerful appearance to the rooms.

It is obvious that in order to obtain uniform footcandle distribution and lower brightness ratios in these rooms additional daylight control equipment is needed. If devices such as venetian blinds or acrylic louvers are installed, then supplemental artificial lighting will be needed to give a uniform distribution throughout the room, thus changing some of the economic considerations of daylight illumination.

In short, if quantity and quality of illumination

Figure 12. Window wall. Evaporative coolers suspended between window walls.

Figure 13. Large overhang over monitor side primarily for walkway coverage.

Figure 14. Test room. Brightnesses in footlamberts. Large expanses of glass like this is Arizona contribute greatly to the room heat gain per hour.

Figure 15. In all test rooms students faced front of room with window wall to their left.

Richard C. Simis School

Figures 12, 13, 14, 15, 16.
Clear glass in large window and clerestory.
No shades at windows.
Ceiling: white acoustical tile.
Walls: white acoustical tile and red brick.
Floor: light tan and brown acoustical tile.
Reflectances: desks, 48%; floor, 17%; front wall, 80%; chalkboard, 40%; brick wall, 8%; ceilings, 85%.
Area outside large window: lawn at floor level extending 50 feet to 5-foot high chain link fence which separates school property from homes and orange tree grove.
Combined readings of the nine test locations — per cent of total readings: over 100 ft-c, 0%; 51 to 100 ft-c, 46%; 31 to 50 ft-c, 42%; 16 to 30 ft-c, 12%; 0 to 15 ft-c, 0%.

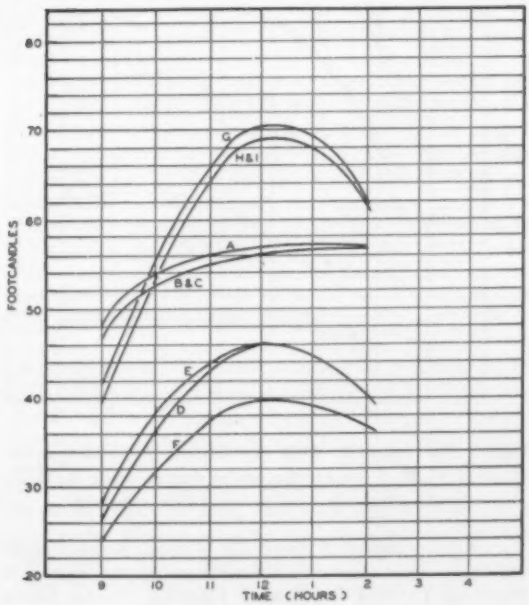


Figure 16. Footcandle distribution recorded for 45 school days in January, February and March 1956.

Figure 17. Note large overhang. Footcandle level higher under sky domes than next to outside window.

Figure 18. Sky domes can be completely blocked with heavy curtain.

Washington High School

Figures 17, 18, 19, 20, 21.

No shades at windows.

Ceiling: light tan acoustical tile. Green ceiling beams.

Wall: light tan acoustical tile.

Reflectances: desks, 25%; floor, 30%; front wall, 60%; chalkboard, 40%; ceiling, 40%; ceiling beams (green), 10%; ceiling beams (tan), 60%.

Area outside large window: lawn at floor level, extending, at a 10 per cent rise, 75 feet to sidewalk and asphalt paved street.

Combined readings of the nine test locations — per cent of total readings: *With Sky Domes* — over 300 ft-c, 3%; 201 to 300 ft-c, 16%; 101 to 200 ft-c, 26%; 51 to 100 ft-c, 22%; 0 to 50 ft-c, 33% (0 to 30 ft-c, 6%). *Without Sky Domes* — over 30 ft-c, 8%; 21 to 30 ft-c, 29%; 11 to 20 ft-c, 47%; 0 to 10 ft-c, 16%.

Figure 19. Exterior roof view of sky domes.

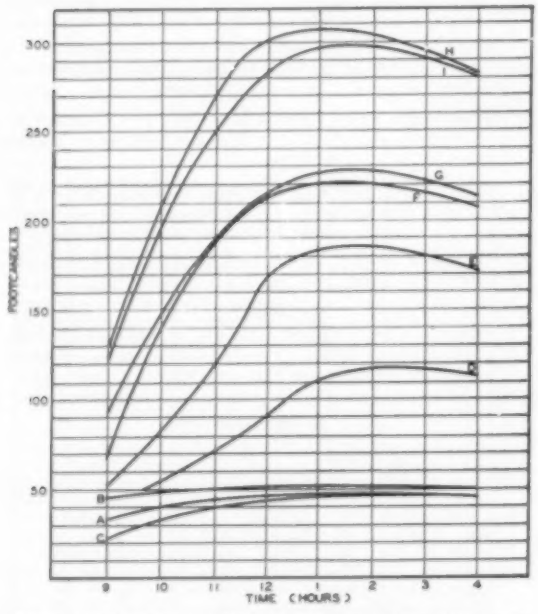


Figure 20. (above) With sky domes. Note that areas D, E, F, G, H, I are erratic under domes while A, B, C, next to outside window are fairly constant.

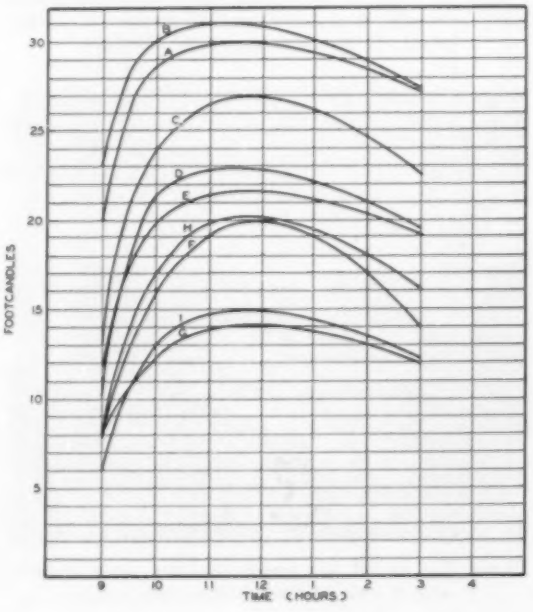


Figure 21. (right) Without sky domes. Room illumination does not meet recommendations by the American Standard Practice for School Lighting. Desks which were used for test stations were not rearranged during test period.

in the classroom are to be equally satisfactory, neither daylight lighting nor electric lighting systems should be considered to render the other unnecessary.

If a broad, general conclusion were to be drawn, it could be said that as yet the use of natural daylight for illumination purposes in classrooms has not been subjected to the precise control that is typical of artificial illumination.

This report has shown what the conditions are in Central Arizona, which are similar to many other areas in the country, particularly in the Southwest. The data in this paper are presented for the purpose of adding a small bit of knowledge to the general art and science of schoolroom illumination.

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2. U. S. Department of Commerce Weather Bureau: "Local Climatological Data with Comparative Data," Phoenix, Arizona, December 31, 1955.
3. Greene, Bernard F.: "Daylighting with Plastic Domes," ILLUMINATING ENGINEERING, Vol. XLIX, No. 4 (April 1954).
4. "American Standard Practice for School Lighting," American Standards Association, Inc., September 20, 1948.

DISCUSSION

WILLARD ALLPHIN:* The author has performed a useful service in making daylight measurements in Arizona which can be compared with those recently made in New England. (ILLUMINATING ENGINEERING, Vol. L, No. 10, page 462.) However, a more complete comparison could be made if he were to make available the readings for the desk receiving the least daylight instead of averaging the readings for several desks in the room.

It is pleasing to note that school children in the Southwest are just as efficient and cooperative as those in the Northeast in making such measurements.

WILLIAM P. CARPENTER:** I very much enjoyed the paper of Mr. Williams because I am tremendously interested in schools.

It was mentioned that electrical luminaires for night usage were provided. I would like to ask the question: Are these luminaires occasionally used during the day or are they in use continuously during the day? It has been my experience that if adequate light is provided and more is available, the user will turn on the additional light because the saturation level for human comfort has not been reached. If it is not a desire to use the electric lights during the day, what has been done to cope with this situation? Do the users simply turn them on as they wish or have certain arbitrary rules been adopted outlining the hours when they may be used?

DOMINA EBERLE SPENCER:† The measurements presented by Mr. Williams are of considerable importance. They indicate the performance of current methods of classroom design in a locality in which daylighting might be expected to be adequate without the addition of supplementary artificial lighting. If daylighting is adequate anywhere, it will be under the clear skies of Arizona.

In roughly 90 per cent of the readings the quantity of light received on the desks is above the value of 30 footcandles given in the current recommended practice. Arizona sunshine reliably produces a satisfactory quantity of light.

But when we consider quality, the story is quite different. The quality of classroom lighting produced by Arizona sunshine is also reliable. The quality is reliably unsatisfactory. The rather meager measurements on the distribution of light in the field of view of the student form a basis of two conclusions. In the first place, for those lines of sight which exclude direct or reflected images of windows, the 3:1 adaptation ratio criterion is generally satisfied. However, if windows are included, the part of the ratio which should be less than 3 is generally on the order of 60 to 80 if the desk top and window are compared. If unilateral lighting were employed, it might be argued that these excessive adaptation ratios could be avoided by a suitable seating arrangement. However, all these schools employ either bilateral vertical windows or supplement the single window wall with plastic domes. Thus, both direct and reflected glare will be present in a large fraction of the probable fields of view. Such a quality of lighting is not satisfactory.

It can be concluded that, even in Arizona, the luminous environments produced by current methods of daylighting are unsatisfactory. If an attempt is made to improve the quality of lighting by introducing louvers, blinds or glass block the quantity will suffer. The lighting of classrooms should be designed to obtain the optimum luminous environment. Both dayligthing and artificial lighting should be integrated to satisfy the 3:1 adaptation ratio criterion for all important lines of sight.

CARL J. ALLEN:* As I previewed this paper I was struck with the fact that daylighting and electric lighting have approached the problem along two entirely different paths. In daylighting design the goal seems to have been to obtain as high a footcandle level as possible with little regard for sky brightness control. In electric lighting the goal has been to obtain only moderate footcandle levels but with a very high regard for luminaire brightness control. In the several illustrations in the paper the north sky brightnesses are shown to be of the order of one to two thousand footlamberts and of large area and in the direct line of view. Certainly there is no comparison between the visual comfort for this source of light and the overhead fluorescent luminaires. The luminaires shown only average a few hundred footlamberts, their total area is less than half that of the fenestration and they are generally outside of the direct field of view. This cerainly bears out the author's conclusion that daylight has not been subjected to the precise control that is typical of artificial illumination.

H. F. KINGSBURY:** It is interesting to see the correlation that exists between the amount of daylight which Mr. Williams' records show they have in Arizona and the amount predicted by the previous paper ("Availability of Daylight," this issue, I. E.).

It would seem that there are several conclusions which can be drawn from this work. Most obviously, Arizona receives a very high percentage of the light possible during the daylight hours. This paper also underlines a problem that faces the engineers and scientists in the daylighting field,

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**Pittsburgh Corning Corp., Port Allegany, Pa.

and that problem is that there are too many buildings "put together" without the benefit of adequate daylight engineering, or by some crude ground rules of orientation. For example, as the author points out, there are no brightness control devices, beyond rudimentary overhangs, in any of the rooms. In general practice, it is this discussor's opinion that no fenestration area should be designed without some form of brightness control, on any elevation, including north, to shield against sky or ground glare.

Secondly, none of these schools, except Washington, receives much, if any light from south, east or west elevations. One of the big reasons for this is unquestionably that "everyone knows you get too much heat and glare from sunny elevations." Any reasonable daylighting design should be able to improve greatly on the designs shown.

Therefore, while many forms of communication can convey what a classroom should look like, for a variety of opinions, wider dissemination of fundamental daylighting design knowledge is required to bring the general level of daylighting design of schools up to accepted standards, whatever material is used to transmit the daylight.

R. W. McKINLEY:* Mr. Williams has added valuable performance data to the growing storehouse. His method has helped to sow the good lighting seed where it perhaps can do a great deal of good. He reminds us that brightness control is a daylighting as well as an electrical lighting problem and he points out that lighting and air-conditioning are closely associated in the overall human environment. For all of this I think we can thank him and be grateful.

However, unless the preprint was in error, I wish to differ with Mr. Williams in his suggestion that the variable characteristics of daylight do not contribute to quality. He did not say that, I believe, in his verbal presentation, but it is in the preprint. The variable characteristic of daylight is, in fact, a major contribution to lighting quality for the following reasons:

(1) It contributes to alertness in the space by avoiding monotony.

(2) It adds to the illumination level and thus increases ease and speed of seeing.

(3) By its variable distribution, color, and level it extends the appreciation of any object in the field of view far beyond what can be obtained in a static visual environment.

(4) Good daylighting can help to reduce the electric lighting bills.

The full utilization of daylight, particularly its variable characteristics is in need of favorable consideration because of the possibilities of improving the utilization of this variable property. To lightly suggest otherwise is, I think, out of character in the context of his factual reporting of data. I think that was excellent.

J. R. WILLIAMS:** I want to thank the discussors for the interest shown in this paper. Their comments have been both encouraging and informative.

In regard to Mr. Allphin's comment that my paper could be compared more comprehensively with his if I had included only the readings for the desk receiving the least daylight, this may be true. If I had done this, my work would have been much easier. Since very few of the footcandle readings, except for Washington High School, were under the American Standard Practice recommended minimum, I believed that the averages shown as curves would be more valuable and readily understandable. I definitely believe that readings from nine positions in the classroom give a better picture for analysis than readings from one position. I also would call to Mr. Allphin's attention the per cent of total readings summary and also the minimum and maximum readings for the middle of the classroom in this paper.

In answer to Mr. Carpenter's questions, I did notice that during the day some of the classrooms were using their electric lights. However, this was only in the rooms equipped with fluorescent fixtures. I never did see the lights being used during the daytime at the Crockett or Clarendon Schools since these two schools have concentric ring 150- or 300-watt incandescent luminaires, as shown in Figs. 6 and 10. Normal procedure at the Washington High School was to use the fluorescent row next to the north window exposure. The reasoning behind this is evident on studying Fig. 20. Footcandle levels are so unequal between window and wall side that teachers try to balance this by using the window row of fixtures.

The other fluorescent equipped school, Richard C. Simis, used their lights at random. Some teachers used them only in the afternoon, some all day and others not at all.

To sum up, I would say, from my observations, that one would find the lights burning frequently unless specific instructions not to do so had been issued by the school administrators.

There is very little that can be added to the comments submitted by Dr. Spencer, Mr. Allen and Mr. Kingsbury except to thank them for their interest in my paper. I hope they do not interpret my lack of comment as insincerity, but rather as a compliment since any further discussion on the discussions would be repetitious.

Mr. McKinley's discussion centering around the variable effect of illumination increasing the appreciation of any object in the visual field is interesting. I believe there is a definite challenge in this field to evaluate the effects of variable light in regard to the relief of monotony and increasing the aesthetic values. However, variable daylight, in my opinion, is a definite deterrent when the source of daylight (fenestration) exceeds those values as recommended in the American Standard Practices. For example, I believe there have been electric lighting installations installed where the footcandle levels could be varied but the source brightnesses have been controlled to the recommended limits.

Another question arises: If variable illumination levels are desirable, at what frequency should they vary? We know that daylight levels can modulate rapidly on a cloudy, windy day. If automatic daylight controls are installed to give us a predetermined level of light, then the economics of natural light could be questionable. And last, I would question the effort expended to date on daylight control with louvers, glass block, etc., if we wanted the variable effects of natural light in our buildings. Naturally, I realize that these external controls on fenestration are also needed to reduce the large sky brightness values. However, I do appreciate that the classrooms presented in my paper have a modern, cheerful atmosphere with none of the students working in the dark.

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**Author.

INSTALLATION IN WASHINGTON, D. C.

Wall Lighting from False Beams

LIGHTING OBJECTIVE: To light a draped wall without interrupting the architectural pattern of the ceiling.

GENERAL INFORMATION: The living-dining room and porch (glass wall between dining room and porch) in which this installation was made is L-shaped. There is a 31-foot 6-inch window running the full length of the wall, common to living, dining and porch areas. The ceiling is slanted from 7 feet 8 inches above this window wall to 12 feet at the peak. Supporting beams 6 x 7-inches run at right angles to this wall on 9-foot centers.

Draperies are creamy white shantung with burnt gold and beige figures; average reflectance, 60 per cent. Panelled walls are of 40 per cent reflectance Korina mahogany. Ceiling is off-white, approximately 65 per cent reflectance and carpeting light tan, a very close match to the panelled walls in color and reflectance.

INSTALLATION: Perpendicular to the supporting beams and 12½ inches from the wall a false beam was installed, intended to look like part of the architectural structure. The purpose of this beam

(over)

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Figure 2. Close-up of false beam installation.

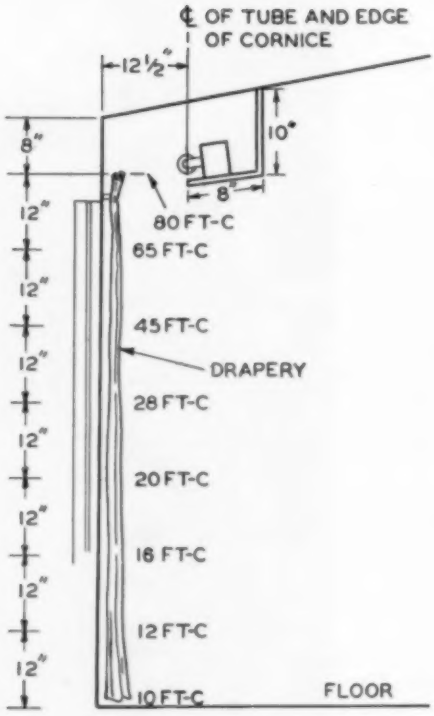

Figure 3. (right) Drawing of false beam lighting installation and resultant vertical footcandle levels down drapery.

is to conceal the fluorescent lamps which light the draperies. One 6-foot T12 slimline and one 15-watt preheat start fluorescent lamp with trigger start ballast, both deluxe warm white color, are used between each of the structural beams. It will be noted from Figs. 2 and 3 that these are placed so that the *center* of the lamps is even with the *edge* of the hollow beam. This placement is critical. Moving the lamps to a point where they would be entirely concealed from directly below the beam would result in a sharp (and visible) cut-off of light about a third of the way down the drapery. Moving the lamps closer to the wall would make them too conspicuous from below and would not improve the distribution of light over the draperies. Figure 3 shows the distribution of light down the draperies with the lamps in the position shown.

In addition to its principal function as an element of general lighting in the room, this installation also contributes 11 footcandles on a book held in normal reading position on the davenport. The table lamps (150-watt, R40 white) add 20-25 footcandles to this.

Lighting data submitted by Mrs. Claire Sidle, Residential Lighting Advisor, Potomac Electric Power Co., Washington, D. C., and Mr. Ben Goodman, National Electric Wholesalers, Inc., Washington, D. C., as one solution to a lighting problem and to aid in the design of similar installations.

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Availability of Daylight

By H. F. KINGSBURY
H. H. ANDERSON
V. U. BIZZARO

As has been reported previously,[1] a project was started in March 1953 at Port Allegany, Pennsylvania to measure the amount of daylight available on vertical planes facing the four cardinal points, as well as the horizontal. The experimental portion of the project was completed in February 1955.

In determining some practical application of the data taken, it is quite obvious that any "average" illumination data, for any elevation or period, is of little value to those interested in determining daylighting requirements for buildings. On the other hand, the number of hours per day the exterior illumination on certain vertical planes can be expected to be above a given level for any month is of value in such design. Therefore, the data obtained were analyzed with this point in mind.

The illumination level on a given face at Port Allegany was plotted at 15-minute intervals from 8:00 a.m. to 5:00 p.m. solar time for each day. Straight lines were drawn to connect the individual points. Two typical plots are shown in Fig. 1 (A and B), for a very clear day and for an "average" day. After such plotting, the total time the lines were above a given illumination level, say 2000 ft-c, was measured.

Table I shows the average number of hours per day that north, east, south, and west were above 1000 and 2000 footcandles during March, June, September, and December of 1953 and 1954. As would be expected, the south face is above both illumination levels for a longer period of time than any other faces at any time throughout the year. As a

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 17-21, 1956, Boston, Mass. AUTHORS: Pittsburgh Corning Corp., Port Allegany, Pa.

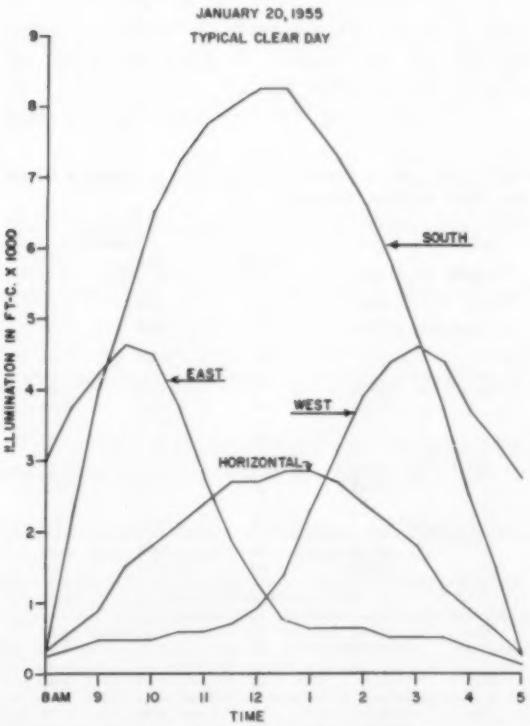

Figure 1A. Illumination received on variously oriented faces during a clear day.

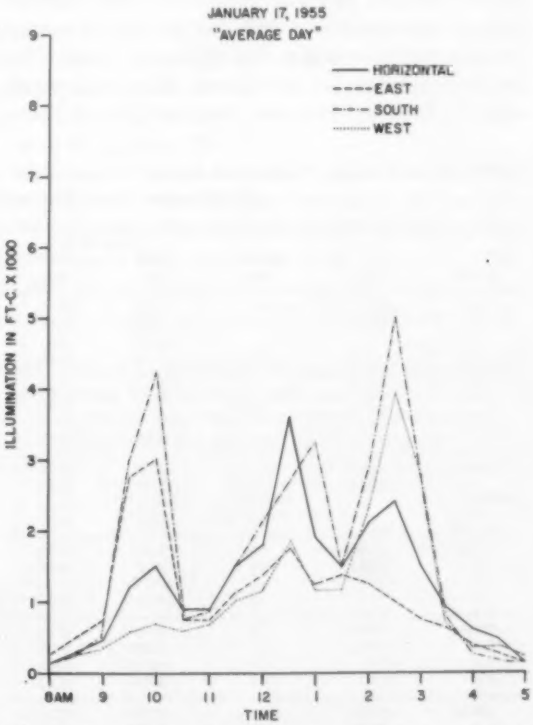

Figure 1B. Illumination received on variously oriented faces during an "average day."

TABLE I — Average Number of Hours a Given Face in Port Allegany was Above a Given Illumination Level between 8:00 a.m. and 5:00 p.m. for Several Months during 1953 and 1954.

Month	Year	Number Days	Hours Above 2000 ft-c North	East	South	West	Hours Above 1000 ft-c North	East	South	West
Mar.	1953	28	0	1.40	2.97	1.72	2.26	3.77	4.66	3.76
	1954	27	0	1.88	3.54	1.87	1.72	3.79	5.17	3.67
		55	0	1.62	3.24	1.79	2.00	3.78	4.91	3.72
June	1953	24	0	2.94	4.37	3.55	4.56	5.60	7.30	5.81
	1954	29	0	2.81	4.18	2.97	4.05	5.54	6.61	4.87
		53	0	2.87	4.27	3.23	4.28	5.57	6.94	5.30
Sept.	1953	21	0	2.74	5.88	2.90	0	4.73	7.11	4.44
	1954	16	0	2.46	5.12	3.07	0.75	4.16	7.07	4.97
		37	0	2.62	5.55	2.97	0.32	4.48	7.09	4.67
Dec.	1953	15	0	0.92	3.24	1.30	0	1.64	3.74	2.08
	1954	30	0	0.86	2.18	0.49	0	1.57	2.89	1.87
		45	0	0.88	2.53	0.76	0	1.59	3.17	1.94

point of interest, the maximum illumination level recorded on the north face during the two-year period was 1920 ft-c.

Since the data available were so extensive, analysis of the information on all five faces would have been excessively laborious and time-consuming. It was felt that the south face would give information which could be applied to the other four faces. The main effort was therefore concentrated on the data obtained from the vertical surface facing south.

Table II gives the average number of hours, between 8:00 a.m. and 5:00 p.m. solar time, a south vertical face was above 1000 ft-c at Port Allegany for each month over a period of the two years. The two-year average for each month is shown graphically in Fig. 2. Over the two-year period, there were data for less than 40 days total for each month of February, August and September. This was caused by mechanical difficulties within the apparatus itself. Both August and September do not fall on the smooth curves drawn through the individual points plotted in Fig. 2, and it would be expected that more data obtained during these months would cause the points for these months to fall closer to the curve. January values would be nearer the curve if only the values for 1954 were used.

The data presented thus far, however, are only applicable to Port Allegany. A means of transferring this information to other parts of the country was therefore sought.

The United States Weather Bureau has, for some

TABLE II — Average Number of Hours between 8:00 a.m. and 5:00 p.m. a South Vertical Face is Above a Given Illumination Level Throughout the Year in Port Allegany.

Month	Year	Number Days	Hours Above 2000 ft-c	1000 ft-c	Month	Year	Number Days	Hours Above 2000 ft-c	1000 ft-c
Jan.	1955	31	3.35	4.81	July	1953	25	4.71	7.38
	1954	28	2.52	3.83		1954	29	4.68	7.31
		59	3.08	4.42			54	4.69	7.34
Feb.	1955	7	3.46	4.49	Aug.	1953	8	3.84	6.32
	1954	28	2.47	3.98		1954	28	4.23	6.82
		35	2.66	4.08			36	4.14	6.70
Mar.	1953	28	2.97	4.66	Sept.	1953	21	5.88	7.11
	1954	27	3.54	5.17		1954	16	5.12	7.07
		55	3.24	4.91			37	5.55	7.09
Apr.	1953	28	2.91	5.00	Oct.	1953	30	5.70	6.46
	1954	18	4.26	5.79		1954	30	3.37	4.69
		46	3.44	5.30			60	4.53	5.57
May	1953	22	2.60	4.95	Nov.	1953	29	2.81	3.83
	1954	23	4.57	7.07		1954	23	3.51	4.43
		45	3.60	6.03			52	3.11	4.09
June	1953	24	4.37	7.27	Dec.	1953	15	3.24	3.74
	1954	29	4.18	6.61		1954	30	2.18	2.89
		53	4.27	6.94			45	2.53	3.17

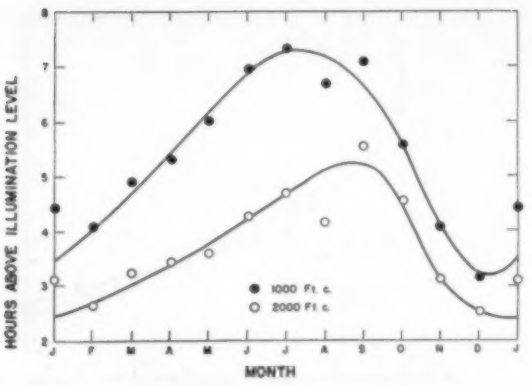

Figure 2. Two-year average for each month.

years, been measuring solar radiation incident on a horizontal surface. Such data are available from approximately one hundred stations quite well distributed throughout the United States.

Because sunlight is a portion of the total solar radiation, it was felt that such horizontal radiation data might be converted to illumination data on vertical planes, providing some means could be determined to correlate such conversions.

Fortunately, simultaneous records of illumination and radiation incident on a horizontal surface were obtained at Washington, D. C. during 1954.[2] The data shown in Table III, obtained from this source, shows that on a monthly average one cal/cm^2 of radiant energy (Langley) is equivalent to 110 ft-c-hrs. of illumination to within 10 per cent for any season of the year. In other words, the ratio between average total radiation and average total illumination is quite constant regardless of the angle of the sun. Therefore radiation data can be converted to footcandle-hours with reasonable precision regardless of the latitude. It is further evident that the ratio is independent of the number of sunny and overcast days, since there are, on the average, more overcast days during October and November than there are during June and July.

The conversion of such total illumination data to useful information on hours above a certain illumination level is dependent, at least at this time, on the development of an empirical relationship, so that this conversion can be accomplished with a minimum of expected error.

Fig. 3 shows the average number of hours between 8:00 a.m. and 5:00 p.m. a vertical surface facing south will be above a given illumination level in Port Allegany. It can be seen that a smooth curve can be drawn through the individual points. Fig. 3 also shows that the curve representing the number of hours above various lighting levels is determined to a large extent by the maximum illumination level attained at any particular moment during any given month. For example, the maximum illumination level for a south face is approximately 9000 ft-c in December and about 4500 ft-c in June. The values would be approximately reversed for a horizontal surface. Since these values are obtained only momentarily and are generally slightly lower even on so-called clear days, because of hazy conditions, the zero intercept of the curve would be slightly below 9000 ft-c for December and below 4500 ft-c for June for a south face. Fig. 3C, in fact, shows the intercept to be at about 4100 ft-c and extrapolation of Fig. 3F would show an intercept at about 9000 ft-c.

It thus becomes evident that a direct conversion of average total footcandle-hours to hours above 4000 footcandles could not be made, nor would it be possible to make a conversion to hours above zero footcandles. Therefore it becomes a matter of making the conversion at that illumination level which gives the least deviation from the mean for every month throughout the year.

Table IV shows a comparison of the average total illumination on a south face between 8:00 a.m. and 5:00 p.m. with the average number of hours that face is above 2600 ft-c, taken from Figs. 3A to 3F, during the same time interval per day at Port Allegany. It is seen in Table IV that one hour above

TABLE III—Comparison of Radiation and Illumination Data Obtained at Washington, D. C.

Date	Number of Days	Average Total Illumination per day in ft-c-hrs	Average Total Radiation per day in cal/cm^2	Ratio	Deviation in Per Cent
June 1954	18	58,200	544	107	3.2
July	20	68,200	567	120	8.6
Sept.	17	48,100	414	118	6.8
Oct.	24	38,800	337	115	4.1
Nov.	28	20,000	198	101	8.6
			Mean	110.5	

TABLE IV—Comparison of Average Total Illumination on a South Face between 8:00 a.m. and 5:00 p.m. with the Average Number of Hours that Face is above 2600 ft-c per Day at Port Allegany.

Month	Average Total Illumination per day in ft-c-hrs	Average Number of Hours Above 2600 ft-c per day	Ratio	Deviation in Per Cent
Jan.	17,450	2.48	7036	7.1
Feb.	16,000	2.34	6838	4.1
Mar.	19,540	2.72	7184	9.4
Apr.	18,300	2.84	6444	1.9
May	17,360	2.66	6526	0.6
June	18,420	2.98	6181	5.9
July	20,025	3.35	5978	9.0
Aug.	20,325	3.25	6254	4.8
Sept.	29,100	4.89	5951	9.4
Oct.	27,700	4.08	6789	3.4
Nov.	19,800	2.78	7101	8.1
Dec.	16,000	2.25	7111	8.3
		Mean	6570	

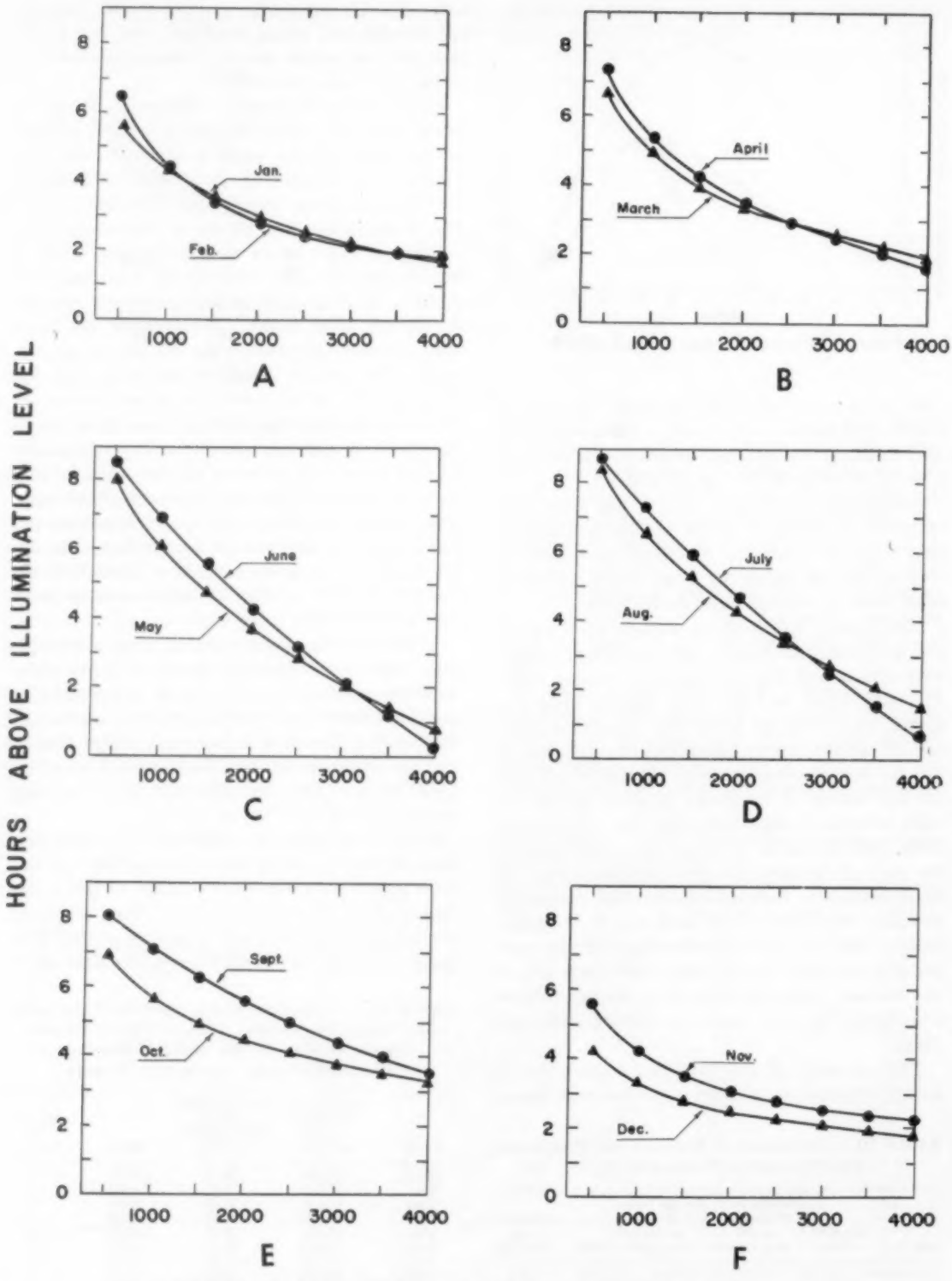

Figure 3. Average number of hours between 8:00 a.m. and 5:00 p.m. that south face is above various illumination levels throughout the year in Port Allegany.

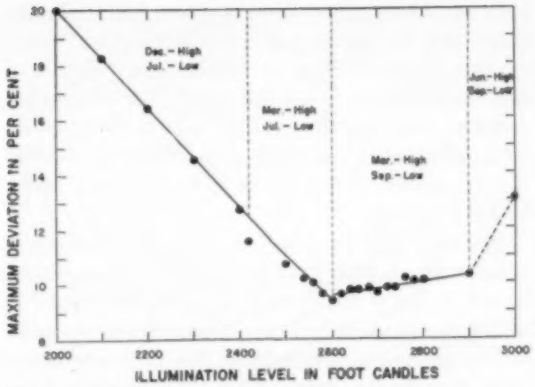

Figure 4. Maximum deviation of the values for any month from the mean when converting average total illumination between 8:00 a.m. and 5:00 p.m. to the average number of hours during this interval above a given illumination level.

2600 ft-c is comparable to 6570 ft-c-hrs, with a maximum deviation of 9.5 per cent. Comparisons at lighting levels above or below 2600 ft-c give larger deviations. Fig. 4 shows the maximum deviations in per cent of the mean obtained when the correlations are made at other illumination levels.

Thus far, it has been shown that it is possible to convert the amount of radiation falling on a particular surface to the number of hours that particular face is above 2600 ft-c. For example, if a particular face receives an average of 200 cal/cm² radiation per day, it would have an average of

$$200 \times 110 \text{ or } 22{,}000 \text{ ft-c-hrs,}$$

which corresponds to

$$\frac{22{,}000}{6{,}570} \quad \text{or} \quad 3.35 \text{ hours}$$

above 2600 ft-c. This conversion has a maximum error of 18.0 per cent. Even though the conversion from radiation to illumination was made from data obtained on a horizontal surface and the conversion from total illumination to the number of hours above 2600 ft-c was made from data obtained on a south face, it is permissible to interchange the factors from one face to another since both were obtained from random conditions of cloudiness and without regard to the angle of the sun. It further follows that the conversion is independent of the latitude.

The advantages of having a vertical surface facing south, as shown in Table I, have not escaped the people concerned with the utilization of solar energy for power purposes. Jordan and Threlkeld[3] have derived maps of the United States showing lines of constant solar radiation falling on a south vertical face during given months. The maps were made possible by the use of ratios of south vertical to horizontal radiation obtained at Blue Hill, Massachusetts, the only observatory recording radiation data on all five faces. A reproduction of their map for January is shown in Fig. 5. It is possible to convert this map to one showing the number of hours a south face is above 2600 ft-c. The number of hours above 2600 ft-c is not, however, particularly advantageous to illuminating engineers. Exterior illumination levels of 1000 ft-c and 2000 ft-c are of more value.

Since the curves shown in Figs. 3A to 3F are characteristic of the particular months as they occur in Port Allegany and deviate by a maximum of three per cent from the points derived from the illumination data, it seems more than fortuitous that this fine agreement occurs. First, it shows that recording of data at 15-minute intervals is sufficient and momentary fluctuations need not be considered when monthly averages are used. Secondly, it becomes evident that in addition to having the zero intercepts fixed by the maximum illumination level reached during a given month, the slopes of the curves are determined to a large extent by clouds and smog.

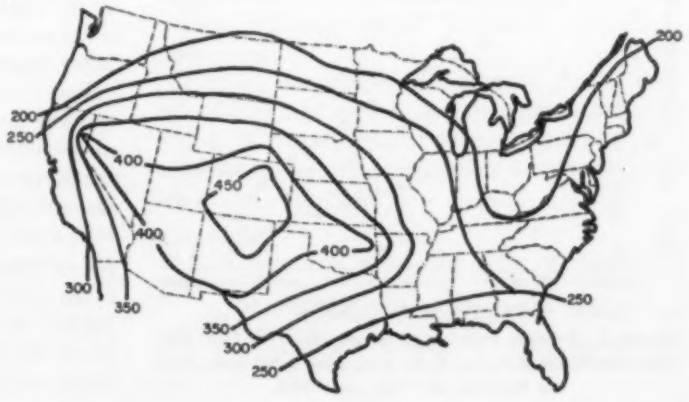

Figure 5. Average solar and sky radiation in Langleys incident on a south face in January (after Jordan and Threlkeld).

A good example of the effects of cloudiness on the curves is shown in Fig. 6. The curves show the average number of hours between 8:00 a.m. and 5:00 p.m. each day a south face in Port Allegany was above a given illumination level during the month of October in 1953 and 1954, as well as the average for the combined two-year period. The hours above certain illumination levels during 1953 are approximately double those above the same levels during 1954. The zero point for both curves, however, would be at approximately the same illumination level. There were 30 days recorded during each October. Hence the difference in cloudiness would be comparable to that shown between various regions of the country in Fig. 5.

If it were assumed that the bottom curve (1954) in Fig. 6 represents the condition in Port Allegany during October and that the top curve (1953) is indicative of the illumination available at "Site X" in some other part of the country, then it would be possible to determine the feasibility of converting the number of hours above 2600 ft-c at "Site X" to the number of hours above 2000 ft-c or 1000 ft-c by using the values shown in Figs. 3A-3F directly. This is not unreasonable since Port Allegany in general has more "overcast" days than most other places in the country. Thus, for example, 2.92 hours are shown above 2600 ft-c on the "Port Allegany" curve and 5.30 hours on the "Site X" curve. It is also shown that there are 3.37 hours above 2000 ft-c on the "Port Allegany" curve. A direct conversion of the 5.30 hours above 2600 ft-c at "Site X" would give

$$5.30 \times \frac{3.37}{2.92} = 6.12 \text{ hours}$$

above 2000 ft-c at "Site X." The calculation gives an error of 7.4 per cent from the value derived from the illumination data. A conversion to hours above 1000 ft-c would result in a 31.7 per cent error by this method. Similar calculations, using the data available at Port Allegany, for the other months of the year show 7.4 per cent to be the maximum error when conversions to hours above 2000 ft-c are made. Hours above 1000 ft-c again show larger deviations.

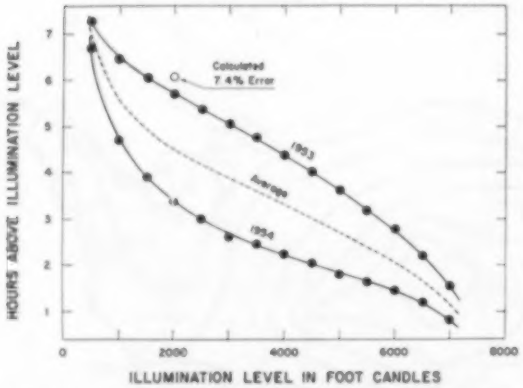

Figure 6. Average number of hours above various illumination levels between 8:00 a.m. and 5:00 p.m. during October of 1953 and 1954.

The maximum error in converting radiation data to hours above 2000 ft-c by the above method would be 8.6 + 9.4 + 7.4 or a total of 26 per cent. It would be expected, however, that greater errors in converting hours above 2600 ft-c to hours above 2000 ft-c would occur when the average total radiation falling on "Site X" during some particular month would be more than twice that falling on Port Allegany. It is felt that the maximum error would then be in the neighborhood of 30 per cent. But, on the other hand, it has been shown that conversion of average total illumination to the average number of hours above 2000 ft-c has a maximum error of 20 per cent (see Fig. 4). In this particular calculation one hour above 2000 ft-c is equivalent to 5335 ±1065 ft-c-hrs. Then, by using this direct conversion, the maximum error for converting average total radiation to average number of hours above 2000 ft-c would be 29 per cent. Accordingly, there is little difference between the accuracies, but the latter conversion has the advantage of being more direct.

Fig. 7 has been prepared by converting the isolines of Fig. 5. The map shows the average number of hours per day the illumination on a south vertical face at different locations throughout the country would be above 2000 ft-c during January. The maximum deviation would be 30 per cent, but it is expected that the curves in the eastern part of the country are more accurate.

While they have not been included in this paper, it is obviously entirely possible to prepare maps similar to Fig. 7 for other orientations and months of the year, and for different illumination levels, using the data contained in Jordan and Threlkeld's paper, previously mentioned, and the material contained herein. While the data expressed on such maps at levels of, say, 1000 ft-c may be subject to errors larger than 30 per cent, they nonetheless should prove of value to those groups interested in the utilization of daylight for room lighting.

The economic aspects of this analysis are interesting. The data compiled in Port Allegany may be taken directly as an example of what might be expected under adverse weather conditions. The Pacific Northwest and the region south of the Great Lakes, where Port Allegany is situated, experience

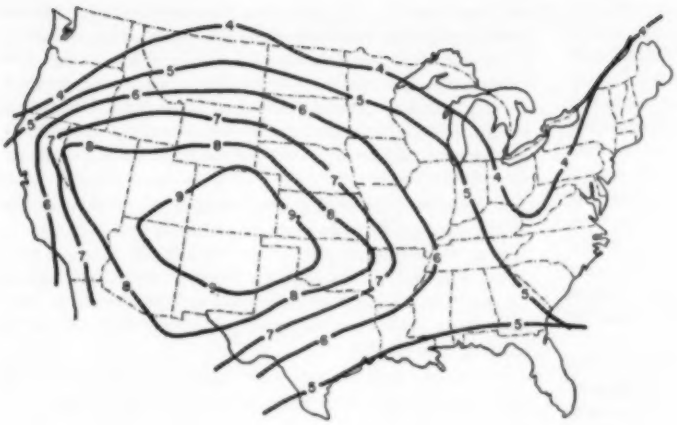

Figure 7. Average number of hours per day during January when the illumination level on a south vertical face is above 2000 footcandles.

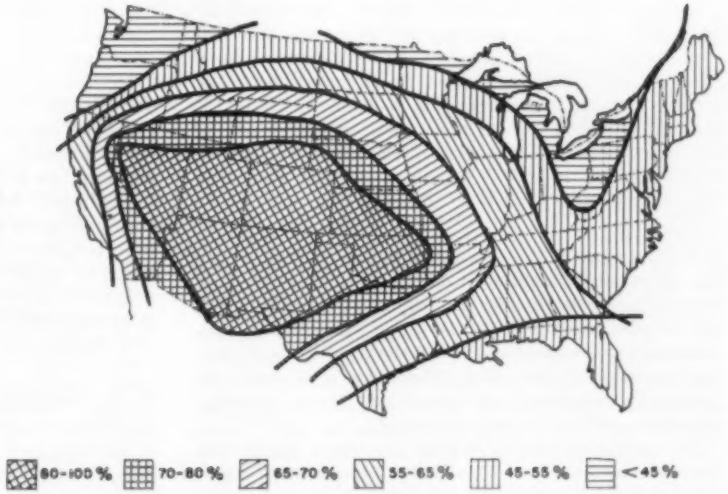

Figure 8. Percentage of time between 8:00 a.m. and 5:00 p.m. when the illumination level on a south face is above 2000 footcandles during January.

the worst conditions for daylighting of any portion of the country (see Fig. 3A). Yet even in this part of the country, and for the winter month of January, 2000 ft-c is available on a south face over 40 per cent of the daylight hours and a correspondingly larger percentage at lower levels, a factor which certainly deserves consideration in building design.

Additional recordings of exterior vertical plane illumination, either in conjunction with radiation data or coordinated with near-by Weather Bureau data are required to further substantiate this present effort. For maximum difference in weather conditions, and testing of the methods contained in this paper, it would be desirable to take such data in a place or places remote from Port Allegany, say west of the Mississippi or in the southwest. Only by such additional data can the methods shown for conversion of radiation data from all parts of the country to illumination levels be verified.

Conclusions

1. A method has been shown whereby radiation data collected by the Weather Bureau from all parts of the country can be converted into useful illumination data.

2. Further substantiation of this method requires the collection of additional illumination data from at least one more source, preferably west of the Mississippi.

Finally, the authors would like to express their grateful appreciation to our Director of Research, Dr. A. H. Baker, without whose keen interest and suggestions the preparation of this material would have been impossible.

References

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2. U. S. Dept. of Commerce, "Climatology Data, National Summary," Vol. 5, 1954.
3. R. C. Jordan and J. L. Threlkeld: "Availability and Utilization of Solar Energy," *Transactions, ASH&AE*, Vol. 60, 1955, pp. 177-196.

DISCUSSION

R. W. McKinley:* I think that this is a most significant paper. Illuminating engineers, like other humans, are inclined to like that which is known and to fear the unknown. It is surprising but none the less true that the availability of daylight, or what I like to call its "dependable service period" has been an unknown in daylighting design. As a result, the traditional design approach has been based on minimum conditions. It is my opinion that these authors in this paper have made a major and basic contribution to the development of illuminating engineering practice. They have begun to remove the unknown. I am confident that there is reason now for changing the basis of daylighting design to "dependable service period."

I hope that there will be an immediate response to the authors' request for assistance in the collection of data in other areas. I shall recommend that the matter be considered by the Technical Advisory Committee of the Illuminating Engineering Research Institute.

Perhaps a reference to Mr. Torrance A. MacDonald, of the United States Weather Bureau, is in line with an acknowledgment which I would like to make. Several years ago, Mr. MacDonald encouraged us to believe that this particular daylight recording work would be fruitful. He suggested that once done there would be an opportunity to correlate the vast collection of *total energy* data available in Weather Bureau records. I believe it was that suggestion that inspired our work at Port Allegany.

J. W. Griffith:** The authors are to be complimented for this nucleus of information on one of the problems that has plagued daylighting designers throughout the country. The type of information demonstrated in this paper for the south elevation should be available for all elevations wherever daylighting design is used. Such information is necessary for good daylighting design applications even though gathering such data would be a large undertaking.

The possible correlation between the radiant energy and the footcandle levels of illumination on a surface would simplify the data collection for the availability of daylight. It would permit the use of years of data already collected by the Weather Bureau. I agree with the authors that it is necessary to compare the Weather Bureau data with illumination values in other parts of the country to verify this technique. Such an undertaking would require the development of rather inexpensive and reliable instrumentations, not available at the present time. It is quite likely that the United States Weather Bureau would be willing to gather such data along with their radiation data if a simple device were developed. The development of such equipment would be a worthy project for the Illuminating Engineering Research Institute to sponsor.

R. A. Boyd:† The authors are to be congratulated on having taken the time to collect and tabulate data on the availability of daylight. The Daylighting Laboratory (University of Michigan) over a three-year period, including the period covered by this paper, collected similar data and we realize how much time and expense is involved in such an undertaking.

The data are presented in a readily usable form and this form or a similar one should be followed when the same information is obtained for other parts of the United States. Since daylighting problems relate to vertical surfaces having a variety of exposures and to the horizontal surface, this information should be extensive as to exposures. Ground reflected light plays such an important part in daylighting design of buildings that these data for vertical surfaces should be extended to include several typical foreground reflectances.

I agree with the authors that more extensive data on the availability of daylight could be obtained from the recordings of total radiant energy. In 1924 H. H. Kimball published some data in the *Monthly Weather Review* correlating illumination and total radiation and it is interesting to note that these results are in rough agreement with the ratios given in this paper.

I sincerely hope that we shall continue to collect data of this type for assistance in better daylighting design.

T. H. MacDonald:* The paper seems to me to be an important contribution to the field of illuminating engineering. The authors come to a result which will surely be useful. In my opinion the importance of the paper would justify a fuller discussion by the authors of the relationship of the shape of the curves shown in Fig. 3 to the solar trajectory and cloud regimes; and of the influence of these elements on the systematic trend with march of the months shown in the deviations in the last column of Table IV. This might further clarify the validity of extending the ratio (average number of hours above a given value of illumination to the mean radiation) to other sections. The test of the validity suggested by the authors — on independent data yet to be obtained — will in any event be important. The authors are to be congratulated on substantially extending the usefulness of available data.

H. F. Kingsbury, H. H. Anderson and V. U. Bizzaro:** It is indeed a pleasure to acknowledge the comments made on our paper and to again express the hope that additional data will be taken to further verify and extend this work.

Since there are but few questions that require further answers, perhaps it is germane to suggest relatively simple means by which these results may be checked by the gathering of additional data at other points throughout the United States. Since the method shown basically involves determination of the number of hours the lighting level is above a certain value on any particular exposure, it should be entirely possible to devise relatively inexpensive equipment to measure "hours above" for any exposure. One suggested method would be to use cosine-corrected and hermetically sealed photocells mounted vertically on any desired exposure. The output of this photocell could then be run through a sensitive type relay, such as manufactured by the Weston Electrical Instrument Corp., to a running time meter recording time in hours and tenths. By presetting the relay, it should be then possible to record directly hours above a particular level with a low expenditure of both money for the original equipment and man hours invested to record the data. A little more elaborate set-up would incorporate a photocell as before and a single point recorder which would draw actual curves of the lighting levels and could be interpreted to read footcandle hours and hours above. A still more elaborate set-up might be to use a double pen

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recorder in combination with both a photocell and a pyrheliometer to record radiation received and light received directly at one location. Automatic switching equipment obviously should be included to turn any one of the instruments on and off at predetermined times.

In regard to Mr. MacDonald's comments requesting fuller discussion of the shape of the curves shown in Fig. 3, general comments only can be offered since the probable shape of these curves is somewhat dependent upon geographical location and weather conditions. For the Port Allegany region, visual and human experience recognize the fact that, for example, December is a month with relatively few clear days, the daylight hours are few, and therefore the curve showing average number of hours above various illumination levels should be quite flat. Conversely, in June, when the sun is more frequently seen and when daylight hours extend beyond the period of our measurements, the curve would tend to be somewhat steeper.

First Approved Lighting Systems for Coal Mines

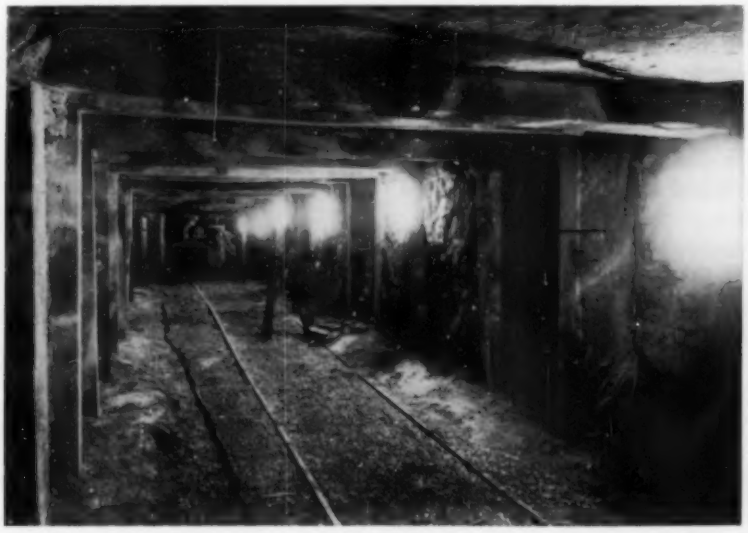
For the first time in history, the Bureau of Mines has approved two commercially made lighting systems as permissible for safe use in gassy or dusty coal mines. These approvals, announced by Secretary of the Interior Fred A. Seaton, were granted after rigorous testing. They fill a need that has existed since mining of coal began, and may bring about one of the greatest advances in mine safety in recent times.

Heretofore, the only light available at the coal face has been provided by the beams of the miners' electric cap lamps, and the headlights of mining machinery. Lack of adequate illumination in coal mine working areas has contributed to many accidents and hampered production, and the hazard has increased with greater mechanization. Until now, however, the fire and explosion risk created by lighting systems drawing current from mine electrical circuits has outweighed the hazards caused by poor visibility. After prolonged study at the Bureau's Central Experiment Station, Pittsburgh, Pa., the Bureau issued standards for testing lighting systems to determine their permissibility for safe use in gassy or dusty coal mines. Two systems have now been approved.

The luminaires of the two approved systems each take advantage of the intrinsic safety of fluorescent lamps when used in an instant-start circuit. Designed to be suspended vertically, and to be spaced at about 18-foot intervals, they are about 18 inches high and six inches in diameter. Each uses two 14-watt fluorescent lamps mounted side by side in a transparent plastic tube. A magnetic lock prevents unauthorized replacement of lamps or tampering, and a short cable and special plug on each unit permits additions as mining advances.

The first approval covers a two-wire distribution system. This is isolated from all other mine circuits by a transformer or a motor generator; it uses 120-volt alternating current. The second approval covers a three-wire distribution system, with the third wire used to ground the metal frames of all parts.

[From a release dated December 10, 1956, from U. S. Department of the Interior, Bureau of Mines.]



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Composing Room

PRINCIPLES involved in good lighting for composing rooms and other printing plant areas are not new. They were studied and expounded years ago, and no wonder: the seeing tasks involved with printing are among industry's most critical. The rule is—use a large-area low-brightness source of illumination. Under such illumination the compositor can inspect type faces by viewing them against the reflected image of the luminaire. Such a system alleviates the chief lighting problem: specular reflection from metal forms, and low contrast between various parts of the metal.

Why then, has it not been routine to install such a system in printing plants? Very large-area low-brightness units have for the most part been custom made and cumbersome. To alleviate *this* problem then, was the objective in planning the lighting for the plant of the *Boston Herald-Traveler*. The entire design hinged on a method of securing the desired visual result with a practicable, low-brightness source, simple, easy to install, and maintain, having the long-life characteristics of an industrial fluorescent reflector but suited to the specialized tasks encountered.

The system installed fully meets these requirements. Essentially, the luminaire is made up of double parallel industrial reflector units having aproximately eight per cent upward component, with diffusing corrugated vinyl plastic across the bottom of the complete unit. The plastic diffuser is held by a frame suspended close to the bottom edges of the reflector. Four parallel rows of 40-watt standard cool white fluorescent lamps are used (two lamps in each reflector). The two parallel reflector units are secured together side-by-side, with the plastic diffuser covering the whole width of the bottom. Corrugations in the plastic are normal to the axis of the lamps. Continuous rows of this combination are mounted seven feet above the floor,

BEFORE: Note brightness streak across metal.

This installation, by Alonzo Taylor, Boston Edison Co., Boston, Mass., won First Prize in the MMILJ contest conducted by the New England Section, and Second Prize in the Northeastern Regional contest.

From levels of 40-60 ft-c (left) with open reflector units to 100-140 ft-c (right) with plastic diffuser units.

Relighted

directly over the composing tables, so that a reflection of the source is produced uniformly throughout the working area as viewed by the compositor.

Certainly the requirements for simplicity and ease of maintenance have been met. As to meeting the lighting and seeing objectives, brightness readings indicate highly satisfactory results. Maintained average illumination is of the order of 115 footcandles. Illumination from the old system varied from 40 to 60 footcandles on the stone. Exposed lamp brightness under the old system was 1900 footlamberts, compared with a brightness of some 500 ft-L for the plastic shielding.

In taking the readings for reflected brightness, a 4-pica base slug was selected as the equivalent of the specularity of a type face. Under the old lighting the brightness varied greatly between the reflection of the bare lamp and the adjacent area. Under the old system, reflection of a lamp was 230 ft-L, with the adjacent area on the work about 19 ft-L. The brightness ratio between the streaks of reflected light of the lamp and the adjacent area was therefore 12 to 1.

Under the new system installed, the reflection of the plastic diffusing was only 95 ft-L, with a ratio within the normal working area of 1 to 1; in other words, a uniform brightness is reflected throughout the task. The area outside the reflection of the diffuser shows a brightness of 15 ft-L, so that in the rare instances when this might come into view, the ratio is still only 6 to 1. The significant point, however, is that with the large-area diffuser, the reflection brightness drops from 230 down to 95 ft-L. At the same time the illumination level is more than doubled, uniformly, over the whole surface of the working area. With this installation, harsh reflected glare has been minimized, a high level of illumination is diffused from one border of the chase to the other, and the typesetter can not only distinguish the details of the work being done, but can do so in comfort.

AFTER: Note improvement in uniformity of brightness.

Interior Lighting with High-Output Fluorescent Lamps

(Rebuttal to discussion appearing with paper, published in the December 1956 issue of ILLUMINATING ENGINEERING)

W. H. JOHNSON:* I would like to express my appreciation to all the discussors for their varied and interesting comments. It is indeed gratifying that this subject is of such interest to lighting men throughout the country.

Mr. Allphin's reference to the use of high-output lamps for cove lighting installations is well taken and I heartily concur.

Mr. Bradley's announcement of a newly developed two-lamp recessed luminaire for use with the high-intensity ballast is of extreme interest. The purpose of the paper, however, was to investigate the adaptability of current luminaire designs for use with the new high-output lamp. It was not the author's intention to imply the impossibility of using this lamp in any one particular type luminaire. I feel the lighting industry through sound engineering and development can overcome almost any problem, as has here been indicated. In certain commercial applications ballast noise will certainly be a problem; however, at the writing of this paper limited information on the comparative noise ratings of high-output ballasts was available.

Mr. Neidhart's preference for a fluorescent lighting system over a fluorescent-mercury lighting system from a standpoint of quality is understandable. A mercury lighting system, however, still has the advantage of a fewer number of luminaires and the smaller physical size of a mercury unit permits mounting in cluttered ceiling areas where an 8-foot fluorescent luminaire is extremely awkward to handle. It is true, for the conditions shown in this cost study, the narrow distribution fluorescent-mercury units could not be mounted at less than 20 feet, but if the illumination level were to be increased the units could be mounted at lower mounting heights. Also, should a localized general lighting system be practical, then these units, even for 50 footcandles, could be used at lower mounting heights. As shown on line 33 of the cost analysis, the total annual maintenance labor cost is extremely favorable for a mercury lighting system and in areas where labor is very high or lighting equipment is very difficult to maintain, this may become a deciding factor in favor of mercury. I would at this time like to include two tables which were completed after the original paper was printed. The first is "Bulb Wall Temperature for Various Commercial Type Luminaires," and the second "Commercial Type Luminaires Ceiling and Suspension Mounting." The first table gives an indication of the rise in bulb wall temperature when various commercial shielding media and the number of lamps per luminaire are changed. It is from this table that one can note the difficulty encountered with a semi-indirect type luminaire. As was pointed out by Mr. Jones in his comments, however, this does not eliminate the possibility of using the 800-ma lamp in this type of equipment. Design changes can make this type of luminaire competitive with existing equipment using 425-ma lamps as regards efficiency. I am more concerned with the increased ceiling brightness which will result from the use of semi-indirect luminaires with the high-output lamps and feel this problem will require additional analysis. The second table points out the ballast temperature problem encountered with surface mounted luminaires. Again, I feel that luminaire re-design and a systematic engineering approach will eliminate this problem.

Bulb Wall Temperature for Various Commercial Type Luminaires.

Luminaire	Mounting	Bulb Wall Temperature Cent.	Fahr.
Bare Lamp (2-Lamp)	Ceiling Mounted	41°	106°
Direct-Indirect (2-Lamp)	24-inch Suspension	39°	102°
Direct-Indirect (4-Lamp)	24-inch Suspension	42°	108°
Semi-Indirect (2-Lamp)	24-inch Suspension	46°	115°
Semi-Indirect (4-Lamp)	24-inch Suspension	52°	126°

Commercial Type Luminaires Ceiling and Suspension Mounting.

Luminaire Type (2-Lamp)	Suspension Distance	Bulb Wall Temperature Cent.	Fahr.	Ballast Temperature Cent.
Bare Lamp	Ceiling Mounted	41°	106°	89°
Direct—30° Louver	Ceiling Mounted	45°	113°	90°
Direct—30° Louver	1-Foot Suspension	45°	113°	87°
Direct—30° Louver	2-Foot Suspension	42°	108°	83°
Direct-Indirect—30° Louver	2-Foot Suspension	39°	102°	78°

It is extremely gratifying to find others in the lighting industry concerned with this problem and to learn that they have run similar tests. Mr. Jones' report of duplication of tests and similarity of results with my own is appreciated. The difference in test results regarding the solid-top industrial luminaire may be due to the ambient temperature during the test. Our test on this lamp and luminaire combination was run at an ambient temperature of 75F. At this ambient temperature the bulb wall temperature may not have been high enough to reduce light output. I have previously commented on Mr. Jones' statements concerning the use of the 800-ma lamp in the semi-indirect type luminaire.

In answer to Mr. Linsday, I can only say that sufficient data were not available comparing various combinations of manufacturers' lamps and ballasts to determine actual in-service lumen values for rapid-start and slimline lamps. The manufacturers' production tolerances in ballast and lamp would require considerable data to be taken before representative values could be arrived at. The efficiencies referred to in Table I were obtained using published manufacturers' data. The illustration indicating higher energy cost for the rapid start installation was only true in the case of the semi-indirect type luminaire where high lamp bulb wall temperature reduced the light output of the rapid-start lamp and required higher installed wattage for equal illumination levels.

Mr. Pennybacker is correct in his statement that light depreciation varies with the watts per unit area; however, this is not the only variable which has an effect on lumen maintenance. The type of fill gas or gases used, the pressure of these fill gases and the chemical composition of the lamp phosphor also have an effect on lumen depreciation. At the writing of this paper, the lamp companies were unable to furnish me with an accurate lumen maintenance figure. At that time it was estimated that lumen maintenance would be approximately the same or only slightly lower than that for the 425-ma lamps.

*Author, Westinghouse Electric Corp., Cleveland, Ohio.

MMILJ Entries Show Current Lighting Trends

New techniques in applied lighting are rounded up from time to time, in IE and in the trade press. Trends are predicted, reported and demonstrated. Ideas are sought, advanced and improved upon. Quietly reflecting these trends in actual installation, however, are the hundreds of jobs presented throughout two countries in the I.E.S. contest for "My Most Interesting Lighting Job." Frequently the "most interesting" aspect is the unusual solution of an unusual problem. More often, though, these installations stand out as gratifying achievements because the application of known principles, plus imagination, has brought similar gratification to the user.

Shown on this and the following six pages are typical installations reflecting many of today's trends in lighting practice. All of them were entries in the 1956 MMILJ competitions.

MODULE—Lighting for the Chevrolet Engineering Center, Warren, Mich., has been coordinated with the architect's plans and with the contractor's work from the "first draft" onward. The architect had laid out the building longitudinally on a two-foot module. Consequently, vinyl plastic rolls for the luminous ceiling of the drafting room shown are in two-foot widths running across the building. Perforated aluminum sound-absorbing baffles are hung directly from every other supporting channel (which hold the plastic in place), a spacing of four feet. Cross baffles four feet long were built into the design for additional acoustical treatment, crossing the longitudinal baffles every eight feet. Plenum for this luminous ceiling is seven feet deep. It houses, completely concealed, all of the heating and air-conditioning ducts, pipes, and other equipments required to service the building. Air, heated or cooled, is forced into the room around the sides of the plastic. Since such equipment in the plenum would substantially affect the amount of light reaching the working surface, a metal reflector sub-ceiling has been provided beneath the pipes and ducts, in 2-foot by 4-foot rubber gasketed pieces directly over the strip lighting. This "ceiling" is approximately two feet above the plastic, and rests directly on the strip fixtures and a T-member suspension. Sprinklers protrude through the metal pan reflector. The fixtures themselves are single-lamp T12 slimline, in continuous rows on two-foot centers, suspended by five-foot rods from the structural ceiling. The lamps are staggered on two circuits in such a manner as to provide one-third, two-thirds or full illumination. Lighting levels in the drafting rooms run 40, 80 or 120 footcandles.

Architect, Argonaut Realty; contractors, Darin & Armstrong and Hall Engineering. Lighting by Donald J. Theisen, Sylvania Electric Products Inc., Detroit. Michigan Section MMILJ.

FLOODLIGHTED BUILDINGS — In addition to the more spectacular floodlighting installations, many buildings are combining civic service with facade display by providing high-level sidewalk illumination. With a total absence of direct glare, the installation for this California bank building blends inconspicuously with the architecture, at the same time attracting attention to the bank's services. Eight-foot custom-made reflector luminaires, each using two rows of 96T12 rapid start lamps at 800 ma, are concealed in the first-story cornice, 35 feet above the sidewalk. Hinged for easy maintenance the reflectors are fully water-tight; ballasts are housed in water-tight cans behind the cornice parapet.

Installation by George Raab, Boyd Lighting Co., San Francisco, Calif. Second prize, Golden Gate MMILJ.

LUMINOUS CEILING PLUS INCANDESCENT LENS — Multiple small beams and large cross-beams on the ceiling of this large (6000 square feet) supermarket are concealed by a luminous ceiling of vinyl strips. General lighting to 80 footcandles is provided by rapid start 4-foot 40-watt de luxe warm lamps in single channels on close spacing. Shadows from the beams have been avoided by mounting the fluorescent channels parallel to the smaller beams with the luminous ceiling mounted flush with the large cross beams. These beams also serve to break the effect of vast expanse of luminous area and afford an attractive architectural treatment. For specialized areas, produce is highlighted to 125 footcandles from 300-watt incandescent lamps with low brightness lens, installed in the luminous ceiling. Over dairy, meat and vegetable cases, 60-watt incandescent units with asymmetric mirrored glass reflectors are recessed on 3-foot centers. A unique type of trap door arrangement is provided at the ends of each aluminum suspension tee for easy removal of the plastic for maintenance.

Installation by H. J. Krietzberger, Pennsylvania Power and Light Co., Hazleton, Pa., and M. J. Davis, Pittsburgh Reflector Co. First prize, Eastern Pennsylvania Section.

THREE ESSENTIAL COMFORTS — Lighting, Acoustics and Air Conditioning — Emphasis on all three of these human comforts in industrial areas, if not a "trend" is in any case becoming more prevalent. Plant managers increasingly appreciate their potential effect on production; leading illuminating engineers advocate all three. At the new Criterion Machine Works in Costa Mesa, California, all three have been provided with visual comfort a major feature. A friendly circle of interflectance of the 90 footcandles of illumination provided by the system is, of course, the dominant factor in this happy circumstance. Walls have been painted a light green having 40 per cent reflectance; machines and other equipment are light gray; cement floors have been brushed with a white cement as a finish coat, to complete the circle of high reflectance surfaces. The white (75% RF) acoustical tile ceiling serves both to absorb excessive noise and to reflect back to the working surfaces light from the 10 per cent upward component feature of the luminaires. Lighting is from 96T12, 430 ma, two-lamp industrial units in continuous rows on 10-foot centers, mounted on 24-inch stems at 12 feet. Daylight glare from the high-transom type windows overlooking the ocean, has been minimized by means of horizontal louvers which themselves may be controlled to coincide with the location of the sun each day. Brightness ratios in this machine shop are in line with recommendations for high-quality office lighting, a feature which is itself becoming a trend for industrial lighting practice. Ratio of task to adjacent surroundings is 2.5 to 1; of task and remote surfaces, 7 to 1; luminaire to surfaces adjacent, 20 to 1, and anywhere in the normal field of view, 37 to 1.

Lighting by Philip L. Martin, Southern California Edison Co., Huntington Beach, Calif. Third prize, Southern California Section MMILJ.

LOW-BAY MERCURY — Contrary to previously accepted mounting heights for mercury units, this installation uses 400-watt color-corrected mercury lamps at a mounting height of only 12 feet. The lamps are used in prismatic reflector luminaires providing 30-degree shielding to the lower tip of the bulb. An upward component of light reflected from a light-colored ceiling contributes considerably to the comfort of the installation. The working area is an assembly conveyor, where it was the goal to provide sufficient light for the assembly of small parts without the use of local supplementary lighting. Illumination level with this system is 75 footcandles.

Designed by Herbert A. Odle, The Holophane Co. Inc., Newark, Ohio. Runner-up MMILJ contest, Cleveland Section.

OUTDOOR-INDOOR TECHNIQUE — Dominant architectural feature of the LaParee Restaurant is the canopy across the entire width of the front (24 feet), extending 11 feet over the sidewalk and back through the glass front to a point 8 feet inside the restaurant. The glass front of the entrance starts some three feet back of the leading edge of the side walls.

Recessed in the canopy are a total of six rows of seven each of 75-watt R-30 pin-hole spots — four in each row outdoors and three indoors. This provides a high level of illumination over the sidewalk and entrance way, and also six lines of light leading into the restaurant. Cove lighting over the center portion of the dining area uses daylight blue fluorescent lamps, and recessed in the perimeter are eight 75-watt R30 floods.

Architects, Shaw and Renneker. Lighting installation by Louis G. Flournoy, Sr., Alabama Power Co., Birmingham, Ala. Second prize, Alabama Section.

SHOPPING CENTERS — Encircling almost every major city these days is one of the most revolutionary trends in merchandising to be seen in several generations. Shopping centers, larger and more elaborate with every year, have themselves served to develop lighting applications peculiar especially to them. As with hundreds of other well-lighted centers, the Los Altos Shopping Center in Long Beach, California incorporates in its lighting design almost every phase of lighting practice; indoors and out. For the parking lot area, which constituted the main feature of this entry, average illumination throughout the enormous parking space is 2.5 footcandles. Street lighting for the adjacent area was planned to be an harmonious part of the Shopping Center lighting, all of course, within the city's requirements, policies and procedures. Fluorescent mercury (700 watts) street lighting units with mounting height of 32 feet 6 inches are on 75-foot to 110-foot spacing, staggered. With future plans to double or triple the size of the center, a series circuit system was felt to be more suitable, rather than multiple circuits, primary feeders and vaults. The system includes: standard 2400-volt-service underground to the utility building; regulators, standard 2400-volt primary 6.6-ampere secondary; 1½-inch galvanized conduits for 5 kv circuit conductors; marbelite standards requiring no painting.

Lighting by Clarence Gabel, Southern California Edison Co., Long Beach, Calif. Fourth prize, Southern California Section.

SILHOUETTE DISPLAY — An eight-foot square low-brightness luminous panel provides a dramatic background for high-quality merchandise in this simple but effective application of the "attraction" principle. The panel is made up of two boxes 4 by 8 feet, one-foot deep, covered with a shoji screen of polyplastic. Ninety-six-inch slimline strips are mounted vertically on one-foot centers; F96T12 de luxe lamps are used. Highlight on the mannequin display is from two 150-watt recessed adjustable spots.

Installation by Grant Radford and Roland Dygert, Pacific Gas and Electric Co., Oakland, Calif. Third prize, Golden Gate Section MMILJ.

RELIGHTING COMBINED WITH ACOUSTICS — The approach to the relighting of the Home Building and Savings Co., Toledo, wrapped several existing problems into one, and the lighting solution paid dividends in improved architectural appearance and a greatly decreased noise level — in addition to 55-60 maintained footcandles.

The bank, last re-done over 20 years ago, had a heavy beamed ceiling construction with many intricate plaster moldings and designs of a by-gone era. An open balcony office at the rear did little to improve the overall appearance, and much to increase the overall decibels.

In the relighting, the beam detail provided a basis for a dropped acoustical tile ceiling and a recessed lighting system of modular design. The false ceiling was lowered to the top

of the pillars, forming a plenum approximately 16 inches deep. Vinyl plastic panels, 2 x 2 feet and of Grecian Square design, are suspended on an aluminum T-bar framework, forming 8 x 8-foot luminous elements. F96T12 standard cool white lamps in two-lamp channels on two-foot centers are mounted on the existing ceiling above. The luminous areas were then boxed in plyboard painted flat white. Along the diagonal wall 4 x 4-foot panels are used, perpendicular to the customer area for conformity in design.

The balcony area was next relighted to recommended levels, and then enclosed with ribbed acrylic plastic. This, with the adequate lighting behind, creates the appearance of a luminous wall from the main floor below.

The large glass block windows, no longer needed as a major source of functional lighting, were partially draped, contributing to the acoustical treatment.

Installation by Jack Felkey, Toledo Edison Co., Toledo, Ohio. First prize, Northwestern Ohio Section.

GYMNASIUM LIGHTING — Several factors combined to recommend the use of a special structure down the center of the ceiling of this Minnesota school gymnasium, housing the main lighting and all the heating ducts. By putting the duct work down one center assembly, the remaining interior of the gym is left clean and uncluttered. The heating system originates in an adjacent mechanical equipment room having a ceiling height of 26 feet; thus a 22-foot height was desirable for the gymnasium assembly. It also developed that this was a convenient height for installation of lighting equipment, since it produced the desired distribution pattern and provided ease of fixture relamping.

Recessed incandescent equipment was chosen, square in shape to fit the openings in the louvered bottom of the assembly, and with a maximum lamp size of 300 watts per optical assembly to keep the fixture brightness pleasant at the 22-foot mounting height. The units are equipped with prismatic high-stress control lenses with an intensive distribution. Lenses will withstand the impact of basketballs and softballs.

After point-by-point illumination calculations, two additional rows of prismatic reflector units were installed in special simple drum housings, one row on each side of the center assembly.

To complete the lighting installation, 32 150-watt floodlights were mounted on 6-foot centers along the top of the center assembly, to provide upward light to the ceiling and balanced brightnesses.

The architects then added gaily colored wooden panels to the end walls for cheerful effect.

Installation by A. W. Lange, The Holophane Co. Inc., and John Quealy of Haarstick Lundgren and Associates Inc., St. Paul, Minn., architects who designed the gymnasium. Runner-up, Twin City Section MMILJ.

HIGH BAY FLUORESCENT — High levels of illumination in industrial areas can hardly be termed a "trend" any more. Quality too has been an accepted proposition for some years now, and high mounting of fluorescent sources is currently a practicable lighting system in many factories. For the lighting in this large machine shop, two-lamp 96T12CW slimline fluorescent luminaires are mounted in 34 continuous rows of 24 units each, at a mounting height of 24 feet at 6-foot spacing. A 550-volt system is used in this plant; 550-volt instant start ballasts are mounted outside the unit in special enclosure cases, staggered to one side and the other of the luminaire.

Even in the very dusty atmosphere encountered, illumination after three months averages 40 ft-c. Ceiling is painted steel, walls are of white-washed concrete blocks.

Lighting designed by Andre Dandenault, Canadian Westinghouse Co., Montreal, Quebec, Canada. Runner-up MMILJ contest, Montreal Section.

GLAMORIZING WITH LIGHT — This is what can be done with light — an imaginative design has transformed a small drab store into a glamorous modern salon. As the lighting has been employed here, it furnishes not only the proper quality for appraising furs, but is also an integral part of the architectural design. Two separate levels of illumination serve to "separate" the cloth coat and suit department from the fur salon. For the fur department, shown here, the ceiling has been painted flat black, as have the walls down to seven feet from the floor. Doors and facings of the fur bins are pale green; carpet is gray-green. A dropped ceiling is suggested by placing the dropped pendant dome lights 10 feet from the floor. The angle of reflected light from the domes picks up cove lights on the perimeter of the room; no spillage of light occurs on the black walls or ceiling. The perimeter lighting in the fur salon uses cool white fluorescent lamps diffused by frosted glass. Recessed, shallow round incandescent units, one blue tinted to accent fur textures, illuminate a customer looking into the large mirror at the rear.

Lighting by Bernard S. Vinick, Sellavision Corporation, Hartford, Conn. Third prize, Connecticut Section MMILJ.

A Uniform Light Source Excited by Radio Frequency

By SANFORD C. PEEK

This paper describes the development of a new small, bright, uniform light source. The light source is described, its development is discussed, and potential applications for the source are examined.

A NEW FIELD has been developed in the lighting industry. In this field illumination is effected through electronic, rather than electric fixtures. The xenon flash tube and power supply, the zirconium arc lamp and power supply, and flashing approach lights for airports are all examples of lamps with electronic fixtures. We might coin the word "lumonics" to describe this combination of the science of electronics and the science of illumination. This paper will discuss another recent development in the lumonics field: the radio frequency lamp.

The radio frequency lamp, or RF lamp, produces light through the induction heating by radio frequency power of a solid disk of highly refractory metal. The light source is small, bright and uniform. The lamp is specifically designed to be used in equipment and processes requiring a rather narrow pencil of light rays, such as projectors, printers, microscopy and color picture tube processing. Fig. 1 is a photograph of the RF Lamp and Power Supply.

Need for a Small, Bright, Uniform Light Source

There is presently a need for a small, bright light source for uses involving a narrow pencil of light rays. For instance, a 16mm movie projector requires a light source of about a quarter inch. A 35mm movie film printer requires a five-sixteenth-inch source. Sources any larger than these are simply a waste of power; smaller sources require lenses that cannot be produced.

In many applications involving a narrow pencil of light rays, the light source must be stable and uniform. Stability and uniformity are now being obtained by sacrificing light through optical tricks such as light diffusion. For instance, light losses in movie film printers by a factor of 4:1 are not uncommon, because to achieve adequate uniformity and stability the present light source requires diffusion filters. There is a need for a small, bright light source that is intrinsically stable and uniform.

Approach to Design Problem

The design of the RF lamp was based on the fact that source brightness, not size, determines the amount of light produced. It might seem that illumination can be increased by de-magnifying a large light source; however, Fig. 2 and the accompanying algebraic equations prove that this is not true.

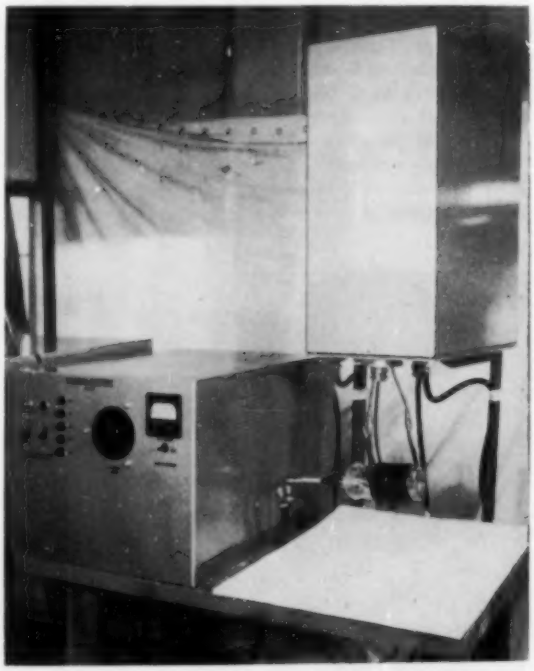
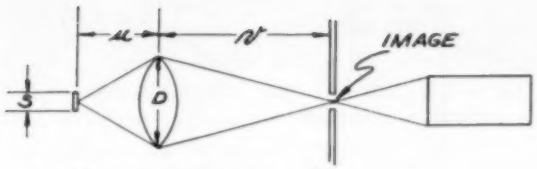


Figure 1. The RF Lamp and Power Supply.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 17-21, 1956, Boston, Mass. AUTHOR: Sylvania Electric Products Inc., Salem, Mass.



1. $N/D = a\ Constant = k$
2. $W \sim D^2/u^2 \times S^2 \times B$
3. $W \sim N^2/u^2 \times S^2 \times B$
4. $M = N/u$
5. $W \sim M^2 \times S^2 \times B$
6. $W \sim B$
7. $f = F/D = k/M+1$

W — amount of light through the system.
f — f-number of the condensing lens of diameter D.
B — brightness of the source.
M — magnification.
F — focal length of the condensing lens.

Figure 2. Optical Arrangement.

Analysis of the equation in Fig. 2 results in two conclusions: first, that only the intrinsic brightness of the source determines the amount of light in the system; second, that the source must be of a certain minimum size so that the optics can be filled with practical f numbers.

With these conclusions established, the physical design of the RF lamp was begun. It was decided to throw all caution to the winds and design a lamp which was as close to the ideal as possible even though the power supply might be bulky or the cost rather high. It was felt that the light source would have the proper characteristics if a solid disc made of highly refractory material were heated to a very high temperature. The light source would be bright if it were sufficiently hot, it would be uniform if a proper method of heating were employed, and it would be stable if the refractory material remained solid.

It was decided to use tantalum carbide as the light emitting material since it is one of the three highest melting materials available today, and is also electrically conductive.* Since filaments could not provide a uniform source and a solid source could not be heated by direct conduction, induction heating of a disc by radio frequency power was tried.

The first attempts produced a lamp which was brighter than a tungsten incandescent lamp, but the life of the lamp was short and the power supply unreasonably large. When the material was pre-processed and the radio frequency efficiency improved, a practical, efficient lamp was produced.**

*The other two electrically conductive high melting materials are Zirconium and Hafnium carbides.

Characteristics — Power Supply

The Power Supply consists of a power supply and an oscillator in two separate cabinets. Cables connect the power supply to the oscillator and transmission lines connect the oscillator to the induction heating coil of the RF lamp. The power supply is a three-phase, full-wave rectifier with associated control components. The oscillator consists of a pair of 833A tubes in a push-pull shunt fed oscillator circuit. Circuit connections from the oscillator to the RF lamp are shown in Fig. 3.

Characteristics — RF Lamp

The light source consists of a $\frac{5}{16}$-inch diameter tantalum carbide disc, called a target, surrounded by a silver plated copper cylinder, called a concentrator, which concentrates the magnetic field at the disc. The induction heating coil of the high frequency oscillator is placed around the lamp closely coupled with the copper cylinder. Therefore, in effect, the tantalum carbide disc becomes the final sink for most of the radio frequency power generated by the oscillator. Fig. 4 is a schematic drawing of the RF lamp.

Performance — Power Supply

The power supply has been certified by the Federal Communications Commission. It has been in use for over five years with no interference reported.

Radiation tests with an RCA 308B field strength

**We wish to acknowledge the help of the Motion Picture Research Council in the early development and evaluation of the RF lamp.

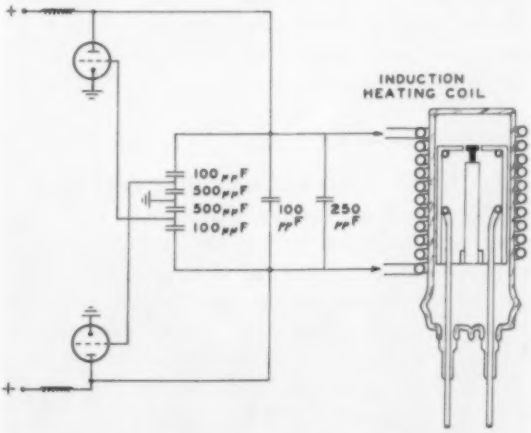


Figure 3. Circuit connections between RF lamp and power supply.

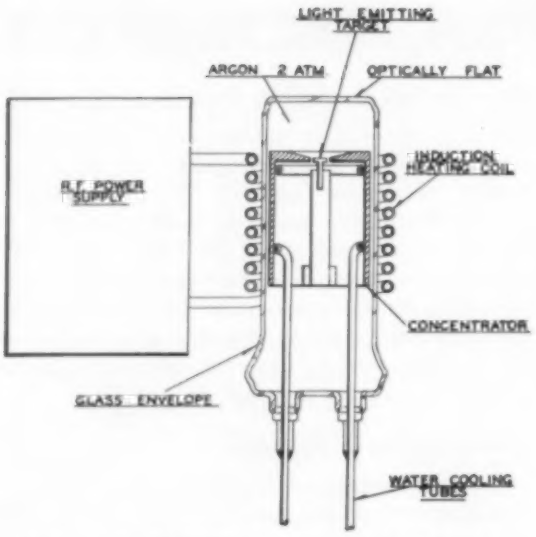


Figure 4. Schematic drawing of the RF lamp.

receiver were made on two power supplies. When the RF lamp was operating at maximum power, the first test was made at a 1000-foot radius through 360 degrees. Radiation was detected and the lob pattern determined. Tests were made then in the radial direction of the maximum lob at a distance of one-half mile and one mile. No signal could be picked up at either of these positions.

The power output of the RF lamp varied as a function of the length of the transmission lines between the induction heating coil and the oscillator. It can be seen from Fig. 5 that the shorter the transmission lines, the smaller the power loss. Fig. 5 also shows that the system is most efficient when the transmission lines are close together; however, since the current is high, it was decided to place the transmission lines about five inches apart to keep the plate current within the limit of the ratings of the oscillator tubes.

Performance — RF Lamp

The length of life and amount of brightness of the RF lamp is graphically illustrated in Fig. 6. In a system involving optics, the most significant measurement is the amount of light picked up by the condensor lens, not the total lumens given out in a 360-degree solid angle as in incandescent lamps. Fig. 6 shows the number of lumens in a plus and minus 50-degree solid angle for various color temperatures of RF lamp operation.

Fig. 6 illustrates graphically how RF lamp life varies with brightness and lumen output. A 750-

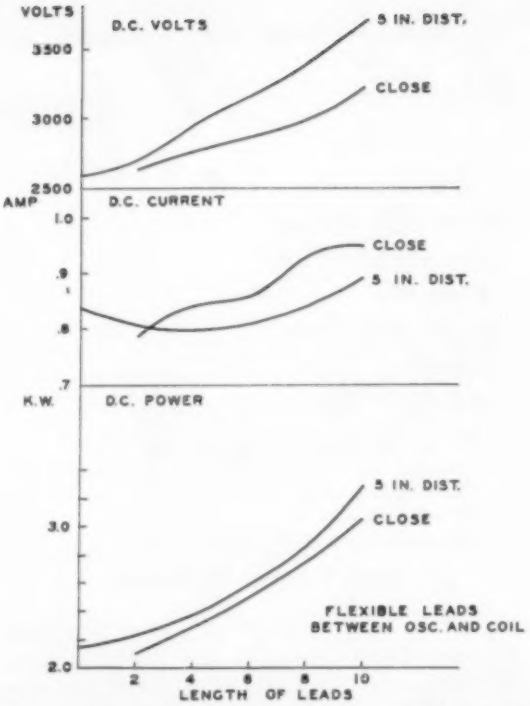


Figure 5. Effect of transmission line length and distance on power output.

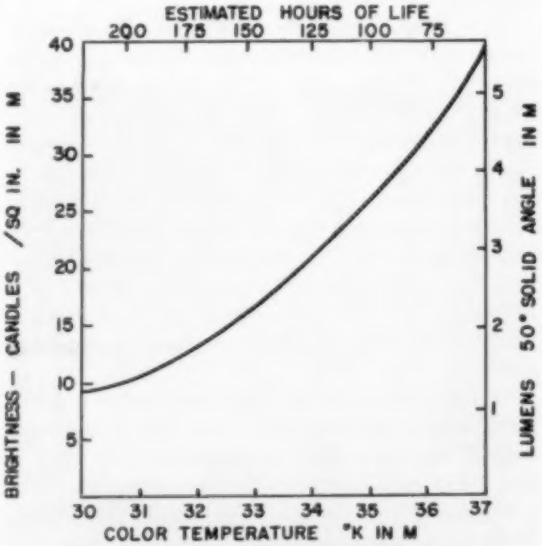


Figure 6. RF lamp life and brightness.

watt biplane projection lamp has an average brightness of about 21,000 candles per square inch. It can easily be seen from Fig. 6 that both longer life and higher brightness can be obtained from the RF lamp than from a biplane projection lamp.

There is a slight inherent non-uniformity in the

brightness distribution on the target surface of the RF lamp because of the non-uniformity of the radio frequency field near the slot in the concentrator, and because of the fact that the radio frequency field generates the greatest amount of heat in the periphery of the target. However, by careful design and positioning of the target and proper design of the concentrator, the circumferential non-uniformity can be held to within four per cent. The variation in brightness between the center and edge of the target is held within 6 to 12 per cent depending on the operating temperature of the lamp. Fig. 7 is a contour map of the brightness variation across the surface of a typical target.

The emissivity of the tantalum carbide target

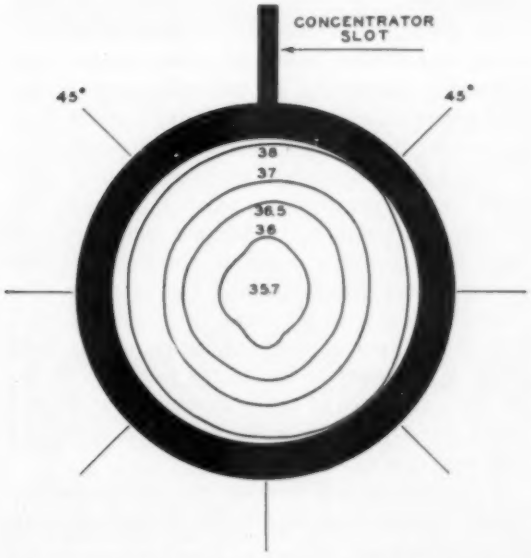


Figure 7. The brightness variation across the surface of the target.

is charted in Fig. 8. To determine emissivity, holes were drilled in the target and the increase in brightness by internal reflection was observed. With the diameter and depth of a line of holes known, the expected gain in brightness can be calculated for different assumed emissitives. The thin lines in Fig. 8 are the assumed emissivity curves, while the thick line shows the actual increase in brightness for holes of varying depths. It can be seen that the emissivity of the tantalum carbide target is somewhere between 0.4 and 0.6.

The spectral energy distribution approximates black body radiation at a color temperature of 3700K. The ultraviolet radiation is limited by the transmission characteristics of soft glass. A mono-

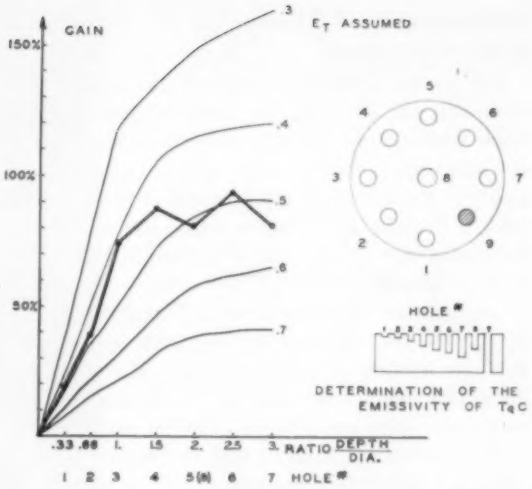


Figure 8. The emissivity of the tantalum carbide target.

cromator and phototube were calibrated with a standard source and factors were determined that could be applied to the RF lamp. The trichromatic coordinates computed from the above factors were found to be as follows: $x = 0.3927$; $y = 0.3766$ and $z = 0.2303$. A plot of these coordinates relative to the planchian locus indicated a color temperature of 3670K which compares favorably with our bi-filter color temperature meter reading of 3700K.

Fig. 9 is a photograph of the image of the light source. The distinctness of the light image and the uniformity of the light distribution of the RF lamp is well illustrated.

Figure 9. The image of the light source.

Applications for RF Lamp

Motion Picture Printer

The motion picture industry is competing with television primarily on the basis of film quality. Color and contrast are the two characteristics that are emphasized in the program to improve film quality. Furthermore, the industry is being forced toward broader and broader color screens. These developments present new problems in the reproduction of color motion picture film.

Until the development of the RF lamp, the standard projection lamp was the only light source suitable for motion picture printing. The standard projection lamp has, however, three major disadvantages: lamps are difficult and time consuming to replace; printing is slow; and the light source is often not sufficiently uniform.

These inadequacies in the standard projection lamp indicate that a uniform, bright, stable light source would be used in motion printing, even if its cost was considerably higher than that of a projection lamp. It must be remembered that in some cases as much as six million dollars is invested in the original negative before printing is even begun. If it takes, as is now the case, up to three months to complete all the release prints, the interest on invested capital becomes quite a significant figure. If printing time can be reduced through the use of a more uniform light source, it would indeed be a worthwhile development. Preliminary tests with the RF lamps showed almost immediately that the use of the RF lamp would result in both improved quality and faster printing.

Preliminary tests revealed minor problems that were eliminated fairly simply. In some cases it was found necessary to regulate the line voltage, since minor changes in line voltage could cause significant changes in light output. General education of the user was found to be necessary. It was also found that control of light output was very important. Small incremental adjustments in light output were necessary to get exact color balance. To obtain these adjustments a control device was developed which is now being made available to the motion picture industry. The vernier control device indicates the relative amount of light produced, and also provides a means of adjusting light output. Fig. 10 is a circuit diagram of the vernier control device.

Several of the major studios in film processing laboratories are now using the RF lamp for film printing. Fig. 11 is a photograph of the RF lamp installed in a printer. Studios are discovering that they can get better film quality and higher printing speeds than can be obtained with any other light source.

Graphic Arts

The graphic arts industry requires a uniform, stable, bright light source for color reproduction. Fluttering, instability or non-uniformity in the light source causes subtle color changes which show up as color inaccuracies in the final reproduction. Standard projection lamps are presently used when small original negatives are printed, but again the process is rather slow. Carbon arc lamps are used when more printing speed is required, yet this lamp requires ventilation and the presence of a licensed operator at all times. Furthermore, with both these types of lamps diffusion of the light source is necessary to flatten the fields. With the RF lamp an image of the light source may be projected directly on the work. Increased speed and improved quality would result.

While work in this field has not reached the production testing stage as yet, the preliminary tests are promising.

Television Tube Processing

The manufacture of the tri-gun aperture mask color picture tube involves a photographic process

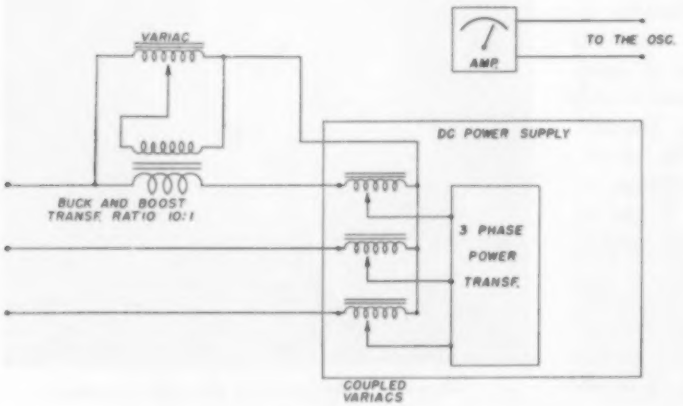


Figure 10. Circuits of the vernier control device.

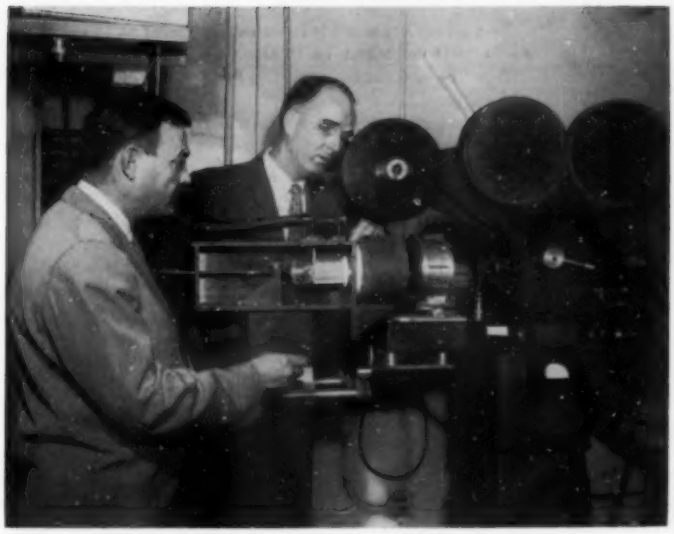


Figure 11. The RF lamp installed in a moving picture film printer.

which very well might employ the RF lamp. Three cathode ray guns shoot electrons onto color dots on the face of the tube. A light source with dimensions which approximate those of the apertures of the cathode ray guns is used to develop the dots photographically and to insure correct positioning of the dots for excitation by the electron beams. The light source must be concentrated, bright, and must have a reasonable amount of light output in the blue region of the spectrum. To the present time mercury vapor lamps have been used as the light source. It was found, however, that the RF lamp could decrease exposure time, and could position the dots more accurately on the tube face. Fig. 12 is a photograph of a color picture tube processing set-up. The RF lamp will probably be an important factor in reducing the cost and increasing the production rate of color television tubes.

Infrared Spectroscopy

There are several thousand infrared spectrometers now in use throughout the country. At the present time the only stable light source for infrared spectrometers is the Nernst Glower. There is a definite need for a stable light source which has a portion of its energy in the infrared part of the spectrum, and which is brighter than the Nernst Glower. Tests are now being conducted on the RF lamp, and it appears that the lamp will be used for this purpose in the near future.

16 mm Projectors

An increase in screen lumens is needed for 16 mm movie projection in many cases. The Armed Forces, for instance, have standardized on 16 mm movie projectors, and yet they find that when they attempt to project cinemascope or other broad screen films, the screen is insufficiently illuminated for viewing by large audiences. The 1000-watt biplane projection lamp provides a maximum of only 800 screen lumens. The RF lamp, providing approximately 1400 screen lumens, would make it possible to show large screen movies in military installations.

Figure 12. Processing a color television tube.

Conclusion

Fixtures for lamps are becoming increasingly complex. The fluorescent lamp, with a fixture involving a transformer and capacitor, was one of the first steps in the trend toward fixture complexity. When the fluorescent lamp was first developed, it was quite difficult to convince manufacturers that prospective customers would be willing to pay thirty or forty dollars for a lamp fixture. There is the same problem to be overcome in the RF lamp with its electronic fixture. Yet the problem will be overcome, since the RF lamp, like the fluorescent lamp, has performance characteristics that cannot be equaled by any other light source yet developed.

DISCUSSION

GEORGE T. HOWARD:* Let us salute investigators like Mr. Peek who have the interest, courage and ability to develop forms of light sources that are radically different from those currently employed. Let us not be critical or disinterested if such new sources, in their early forms, appear to be complex or to require complicated auxiliaries.

In the field of applications every exponent, every developer, of a new source seems to have to face the question: What can it be used for? The author, we suspect, has also had to do this because it is expected of him. We wish our investigators were not pushed into this area, but it does result in questions which he has opened.

First he mentioned graphic arts. One possible application of a source like this might be in the projection of color transparencies on a screen from which they may be copied. But it would seem that this is a rather minor application. Color transparencies are, for the most part, copied directly without need of projection. So, question 1: are not the major applications of light sources in the graphic arts industry either those employing long tubular sources, such as the black and white printing and copy board lighting, or an illuminant which is rich in radiation in the vicinity of 3650 Angstroms as in the case of vacuum frame printing, rather than a more uniform brightness? Source brightness and uniformity of brightness are not of major importance in most of these applications.

In color television tube processing we need brightness as well as spectral quality, but the spectral energy needed is not only in the blue, as the author states, but also in the near ultraviolet in order to activate the bichromate sensitized binders used with the color phosphors. The mercury lamp presently used in this application has a very high brightness in the visible, 195,000 candles per square inch, and an even greater relative concentration in the near ultraviolet. So, question 2: is Mr. Peek really very optimistic about this application of the RF source?

Mr. Peek mentioned a possible use in 16mm projection equipment which implies and requires a very high degree of portability. Would we infer from this, question 3: does he anticipate some rather major reductions in the size of the power supply in order to achieve portability?

The fourth question: is it too early to offer any predictions as to what we might be thinking of in terms of efficiency and lumen maintenance and life and failure characteristics?

Fifth and last: we are a little startled by one statement in the paper which may or may not have come through as it was intended. In comparing the potentialities of this source with the tungsten filament sources in one case Mr. Peek points out one of the disadvantages of tungsten filament sources is that the lamps are difficult and time-consuming to replace. That may not have been the way he meant it; however, that is the way it is worded in the paper. We visualize a very simple press and twist for the removal and insertion of a prefocus type of lamp and this seems simple when compared with the plumbing and high frequency equipment that goes with a radio frequency source.

S. C. PEEK:* The questions raised are certainly worthwhile for they will bring out some important points which were neglected in my previous presentation. I will take these one at a time.

Graphic Arts. The need for a uniform light source for graphic arts arises from the need for more uniform illumination on the object to be photogaphed. With proper optics such as the Schmidt system or a large reflector, it is possible to form an image of the RF lamp directly on the object to be photographed. Thus, a very efficient use of the light source can be obtained and under certain circumstances improvements in speed can be obtained even over a carbon arc.

Color Television. Although the RF lamp is not being used in color TV tube processing in an actual production operation, it looks hopeful again because of its uniformity. Although it has less UV than a mercury lamp, the fact that the optical efficiency can be made much greater with a uniform source makes improvements in speed possible.

16mm Projection. We are not here discussing the possibility of the RF lamp in an amateur 16mm projector but rather for the professional type used in schools or by the military. Here gains in screen brightness are very worthwhile especially in view of the need for larger screens, such as cinemascope. The use of the RF lamp makes it unnecessary to have licensed operators such as is the case with carbon arcs.

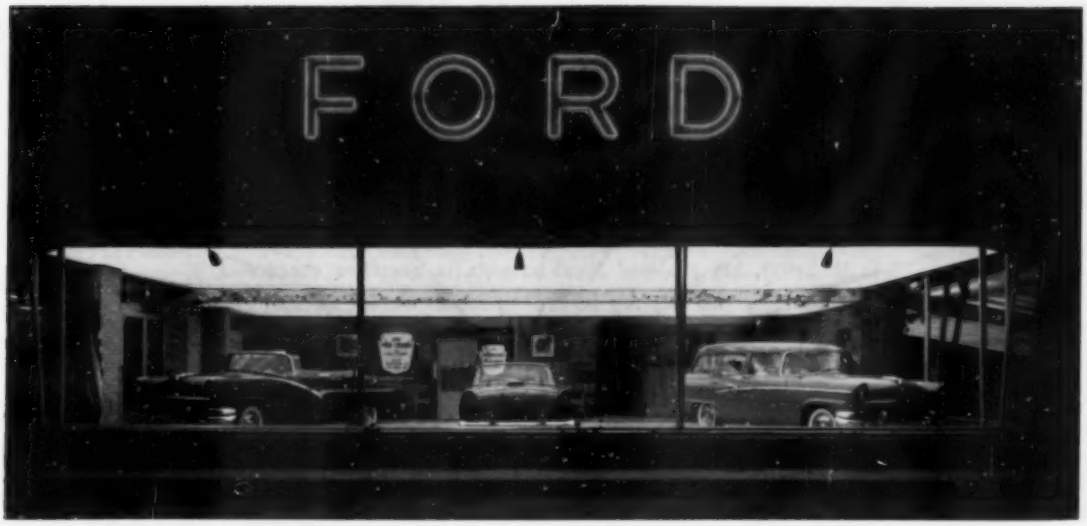
Life and Maintenance. We have obtained extensive life information and it appears that the lamp will operate well in excess of 100 hours at its rated operating voltage. Its maintenance is 100 per cent since in its normal use the power supply is turned up to higher powers in order to maintain constant light output. The final determination of life end point arrives when the power supply can no longer deliver enough power to maintain the light output at the initial level.

Replacement Ease. A tungsten filament lamp in a motion picture printer is not easy to replace in that field uniformity has to be tested each time the lamp is removed. The RF lamp has such extreme uniformity that the ease of replacement is relatively simple. Naturally, the RF lamp is not as easy to exchange as an ordinary household lamp.

We fully realize that the RF lamp has plenty of practical disadvantages. On the other hand, we feel that it is a step toward a new light source with inherent characteristics that can be used in many specialized applications.

*Application Engineering, Large Lamp Dept., General Electric Co., Cleveland, Ohio.

*Author.



INSTALLATION AT TAIT MOTORS, LINCOLN HIGHWAY EAST, COATESVILLE, PA.

Lighting an Automobile Showroom

LIGHTING OBJECTIVE: To provide a high level and good quality of illumination for the merchandising of new automobiles.

GENERAL INFORMATION: This showroom is approximately 45 feet 6 inches long and 33 feet wide. Height from floor to luminous ceiling is 10 feet. Plenum depth is 14 inches. Colors and reflectances are as follows:

Plenum			Walls		
Ceiling	white Celotex	75% RF	Rear	light mahogany	21% RF
Sides	white concrete	70% RF	Others	glass	——
Plastic ceiling	vinyl plastic	55% RF	Columns	brick	40% RF
			Floor	gray	4% RF

INSTALLATION: General illumination is provided by 78 Benjamin single-lamp fluorescent units, catalog No. NHS-2-196, surface mounted in rows on 24-inch centers above the Benjamin Panelglo vinyl plastic ceiling. Each unit is equipped with one 96-inch T-12 standard cool white slimline fluorescent lamp.

Supplementary illumination is provided by five Swivelier catalog No. B81 adjustable incandescent units mounted on the perimeter of the luminous ceiling on 14½-foot centers. Each unit is equipped with one 150-watt R-40 colored spot lamp.

After 1500 burning hours the general level of illumination was 125 footcandles. Brightnesses were as follows: luminous ceiling at 45°, 180 ft-L; rear walls, 13 ft-L; columns, 24 ft-L; floor, 5 ft-L.

Lighting designed by Michael N. Flynn, District Representative, Benjamin Electric Mfg. Co., and S. W. Purdum, Lighting Engineer, Philadelphia Electric Co.; General Contractor, C. Timothy Slack, 129 South 5th Ave., Coatesville, Pa. Electrical Contractor, C & W Electric Co., Coatesville, Pa.

Lighting data submitted by George T. Anderson, Jr., Lighting Engineer, Philadelphia Electric Co., 211 South Broad St., Philadelphia, Pa., as an illustration of good lighting practice and to aid in the design of similar installations.

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A.I.A. File No. 31

Questions and Answers on light sources

The I.E.S. Committee on Light Sources, under the chairmanship of E. H. Salter, has prepared these answers to questions concerning light sources. Readers are invited to submit similar questions of general interest to be considered for publication. Questions should be sent to the Committee in care of Society headquarters.

What is the average decrease in light output of daylight, cool white and white fluorescent lamps in the first 100 hours of operation?

The drop in light output during the first 100 hours will be approximately 5 per cent. This is less than half of the 100-hour depreciation in light output when fluorescent lamps were first introduced seventeen years ago.

Is there any advantage in turning fluorescent lamps off during lunch periods? At present in our building the lamps are turned on at 8:00 a.m., off during the one-hour lunch period, and then on again for the afternoon. Also, if executives leave their offices for an hour or two, the lights are switched off for the duration of their absence. We have been told it would be more economical to turn the lamps on only once a day, and not turn them off until employees leave in the evening. What are your recommendations?

The question of whether fluorescent lamps should be turned off during lunch hour, or left on, was originally based on the premise that fluorescent lamp life was considerably shortened by intermittent operation. In the early years of fluorescent lighting, the life of fluorescent lamps was materially reduced if they were burned on a short burning cycle. Therefore, many users of fluorescent lamps hesitated in turning off these lamps during lunch hour. In recent years, many improvements in fluorescent lamps have resulted in considerably longer life, and therefore, any detrimental effect on life due to turning them off during lunch hour has been very much reduced.

There are many factors to be considered in determining whether there will be a substantial saving in turning off fluorescent lamps during lunch hour or whether it is more economical to let them burn.

(1) Length of time for lunch period.

(2) Savings in cost of electrical energy, which would also depend upon the cost of kwh.

(3) Safety hazards as a result of lamps being turned off.

(4) Inconvenience due to lamps being turned off.

It is difficult to place a monetary value on the latter two items. It is easy enough to calculate the exact savings in electricity when lamps are shut off during lunch period. It can be calculated by multiplying the entire electrical load of the lighting system by the time and the cost per kwh. Incidentally, this saving would take place whether the lamps are incandescent or fluorescent.

The question of whether lamps should be turned off usually only occurs with fluorescent lighting because it allegedly reduces the lamp life and therefore would cause some increase in expenditure for lamps. Probably the most important factor here is the length of time that lamps will be turned off. Generally, if the shut-off period is less than 20 minutes in most installations, it is uneconomical to shut off the lamps. The longer the period that lamps are turned off, the more substantial will be the savings in electrical power to offset any small reduction in lamp life.

In summarizing, because of the longer life, in general, of fluorescent lamps, the question of turning them off during lunch hour is pretty much dependent on the savings in electrical power taking into account safety and convenience rather than the effects on lamp life. In other words, for all practical purposes a fluorescent lighting system can be considered the same as an incandescent one in most cases to determine what savings can be effected.

Lighting Outdoor Locations Of Central Station Properties

Prepared by the Subcommittee on Lighting of Outdoor Locations of the Committee on Lighting of Central Station Properties of the Illuminating Engineering Society

Foreword

The lighting of Central Station properties, and especially generating and substation areas, presents many peculiar seeing problems and conditions which are not typical of work areas in general. Accordingly, in 1948, the I.E.S. Council established a Committee on the Lighting of Central Station Properties to study conditions and prepare general recommended procedures to serve as a guide for the industry. Three of these reports, "Lighting of Control Rooms," "Lighting of Load Dispatch Rooms," and "Lighting of High Bay Areas" have already been published.

Another report which is scheduled for the near future is "Lighting of Indoor Locations."

It is planned that all five of these reports shall be in acordance with latest knowledge and practices. However, future progress in the art and science of illumination will doubtless make a revision of these recommendations desirable.

SUBCOMMITTEE ON LIGHTING OF OUTDOOR LOCATIONS

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H. F. Carroll — D. J. O'Neill

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1. Introduction

(a) Lighting outdoor areas of central station properties poses problems in illumination pertaining to many phases of exterior lighting practice. Requirements range from the lighting of a building for advertising purposes to the lighting of coal piles and from walkway lighting to the lighting for entrance gate areas. Since generating stations operate around the clock, it is important that adequate and proper lighting be available at all times. This report is based on a study of existing installations and practices and on the latest engineering data covering service requirements and available lighting equipment.

(b) The scope of this report includes design data and an analysis of the fundamentals of good lighting and the special lighting requirements of generating stations. Also included are pictorial records of typical lighting installations.

2. Seeing Tasks

The seeing tasks encountered in outdoor areas within the power plant site vary widely. The ability to see is primarily dependent upon the level of illumination, the size of the object, the brightness contrast, the absence of objectionable glare and the time available for viewing.

2.1 — *Size* — As size increases visibility increases and, up to a certain point, seeing becomes easier.

2.2 — *Brightness* — Brightness resulting from the light on the task and its surroundings in the visual field may be controlled within wide limits by varying the amount and distribution of light. The brightnesses needed for good seeing are usually many times those necessary for mere discernment; with higher brightness one may, to some extent, compensate for deficiencies in size, contrast and time of viewing.

2.3 — *Contrast* — To be readily visible, each critical detail of the seeing task must differ in brightness (or color) from the surrounding background. Within the limits available to industry, the contrast of seeing tasks, *i.e.*, between the object and its background, should be made as high as possible to reduce the need for much higher illumination levels that would otherwise be necessary.

2.4 — *Glare* — Glare may be defined as any brightness within the field of vision of such character to cause discomfort, annoyance, interference with vision, eye fatigue, etc. To reduce glare in outdoor lighting applications, the most feasible expedient is to increase the angle between the glare source and the line of vision by mounting the lighting equipment as high as practicable. In some instances, glare reduction may be practicable by reducing the brightness of the light source and utilizing more sources to obtain a desired illumination level.

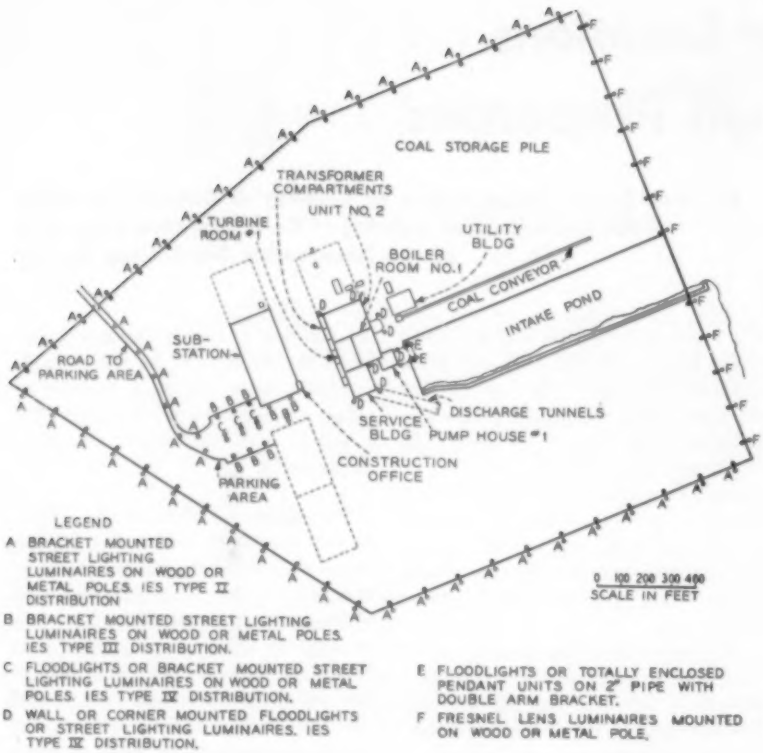
2.5—*Time of Viewing*—By increasing brightness, time required for seeing will be shortened. In outdoor areas, adaptation time of the eye must be considered when specifying the overall lighting facilities. The eye requires time to adjust to the different brightnesses and, therefore, in the interest of safety and expediting work, associated areas must not have extremes of brightness.

3. Applications

3.1 — *General Applications* — This section covers general applications which are characteristic of Central Station properties.

3.1.1—*Protective Lighting*—**(a)** Fence boundary lighting and, in general, protective lighting may be applied in special situations. While the current American Standard Practice for Protective Lighting treats this subject more broadly, this section points up the more pertinent aspects that should be considered.

Approved by the Council of the Illuminating Engineering Society, October 1955.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TRANSFORMER COMPARTMENTS
UNIT NO. 2
TURBINE ROOM #1
UTILITY BLDG
BOILER ROOM NO.1
COAL CONVEYOR
INTAKE POND
SUB-STATION
ROAD TO PARKING AREA
DISCHARGE TUNNELS
SERVICE BLDG
PUMP HOUSE #1
CONSTRUCTION OFFICE
PARKING AREA
LEGEND
A BRACKET MOUNTED STREET LIGHTING LUMINAIRES ON WOOD OR METAL POLES. IES TYPE II DISTRIBUTION
B BRACKET MOUNTED STREET LIGHTING LUMINAIRES ON WOOD OR METAL POLES. IES TYPE III DISTRIBUTION.
C FLOODLIGHTS OR BRACKET MOUNTED STREET LIGHTING LUMINAIRES ON WOOD OR METAL POLES. IES TYPE IV DISTRIBUTION.
D WALL OR CORNER MOUNTED FLOODLIGHTS OR STREET LIGHTING LUMINAIRES. IES TYPE IV DISTRIBUTION.
E FLOODLIGHTS OR TOTALLY ENCLOSED PENDANT UNITS ON 2" PIPE WITH DOUBLE ARM BRACKET.
F FRESNEL LENS LUMINAIRES MOUNTED ON WOOD OR METAL POLE.
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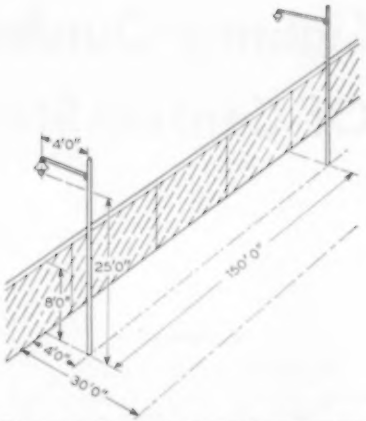


Figure 1. Layout of typical generating station showing use of various types of protective lighting equipment.

(b) The aim of protective lighting is to promote safety and security from sabotage. Light is used to reveal the saboteur, while darkness conceals the guards. In this application, glare is utilized to blind the trespasser and to obscure the guard. It is important to ensure that the guards' eyes remain dark-adapted; therefore, care must be exercised that their eyes are shielded from all glare.

(c) Table I lists equipment used for protective lighting, and Figs. 1 and 2 illustrate applications of this equipment.

3.1.2 — *Pedestrian and Conveyance Entrance Lighting* — Entrances may be classified as active or inactive depending on whether or not they are constantly attended and authorized for use at night. Only active entrances, except in protective lighting applications, are normally lighted. In this classification fall the watchman's gate and the entrance for truck deliveries. Identification of personnel, visitors and vehicles entering or leaving the plant property (Fig. 3) is important for prevention of theft and maintenance of security. The general lighting must be adequate for the recognition of pedestrians and inspection of passes. Special lighting should be provided and luminaires properly located so that persons inside a truck, cab or automobile may be identified without getting out of the vehicle. For details on this subject

Figure 2. Outdoor storage area lighting.

Figure 3. Pedestrian and conveyance entrance lighting.

refer to the current American Standard Practice for Protective Lighting.

3.1.3 — *Roadways* — The lighting of roadways on plant property is treated in the same way as public street lighting and the American Standard Practice for Street and Highway Lighting should be followed. These roads are classified as light traffic streets and require a maintained footcandle level on the pavement as indicated in Table II. Higher illumination levels are sometimes provided for display or publicity purposes. Railroad sidings should be treated like roadways. Roadway intersections should be treated in accordance with the American Standard Practice for Street and Highway Lighting. Figs. 4 and 5 illustrate some typical methods of approach.

3.1.4 — *Open Yard Lighting* — Frequently traveled paths on the station property include walkways from parking lot to building entrance, building to transformer yard, etc. These should be lighted for safety as well as convenience. Small lamps in outdoor luminaires (Fig. 30) may be used. If the spacings are great, the use of street lighting luminaires (Table I) may be advisable. Floodlighting may be applicable under proper conditions. Fig. 6 illustrates a typical solution using floodlights.

3.1.5 — *Outdoor Storage Areas* — As in the previous section the application of systems of lighting depends upon the size of the area. When storage areas are small and the possibility of a crane swinging into the lighting unit is remote, street lighting luminaires may be used to generally illuminate the area. In larger areas and especially where long-boom cranes are used, floodlighting is a more accepted practice. Fig. 2 illustrates a typical application.

3.1.6 — *Parking Areas* — Parking areas may be lighted in a variety of ways depending on the arrangement of the parking lanes. In many instances a general floodlighting scheme is satisfactory. The floodlights should be mounted on relatively high structures and distributed in such a manner as to reduce the possibility of shadows and glare in the eyes of the motorists. Street lighting luminaires may also be utilized in areas along rows of cars providing for

Figure 4. Roadway lighting using typical pole-mounted luminaires.

Figure 5. Roadway lighting using wall-mounted luminaires.

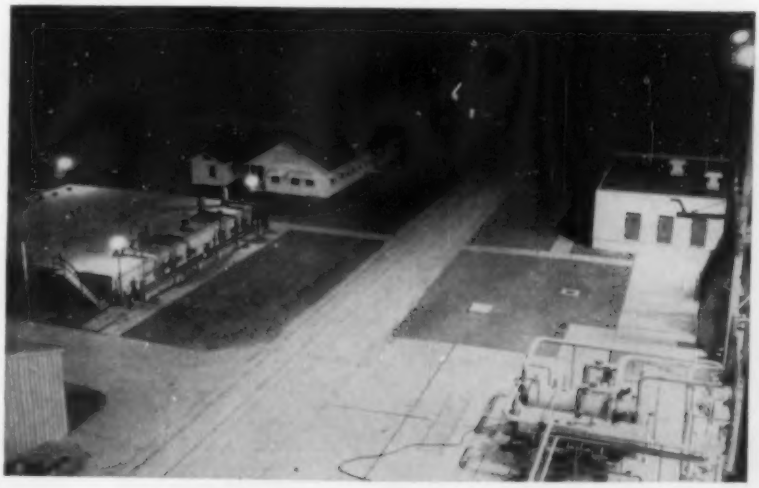


Figure 6. Yard floodlighting.

Figure 7. Parking area illuminated by street lighting luminaires.

width of area coverage equivalent to streets. Reflectorized lamps are a convenient source of illumination when small parking lots are lighted. Fig. 7 illustrates a typical method of lighting parking areas.

3.1.7 — *Obstruction Lights* — The requirement for obstruction lights on the boiler stacks, transmission towers and similar high structures can best be determined by referring to rules established in the publication "Obstruction Marking" by the Civil Aeronautics Administration, U. S. Department of Commerce.

3.1.8 — *Entrances to Buildings* — Entrances to buildings may be provided with a wall bracket on which either plain or ornamental luminaires with general diffuse distribution are mounted. Often the entrance facade is especially designed for installation of recessed luminaires or reflectorized lamps to provide a highlighted area at the entrance. Street lighting luminaires and floodlights have also been used. See Fig. 8.

3.2 — *Specific Applications* — This section covers the more specific areas which are usually encountered in generating, transformer, switching and unit stations.

3.2.1 — *Fuel Delivery Areas*

3.2.1.1 — *Coal* — **(a)** When coal is delivered it must be unloaded from barges, freight gondolas or motor trucks. In the case of barge deliveries of coal, the important areas to light are the inside of the barge (Fig. 9), the bucket crane dock, the coal tipple and the entire length of dock. In some instances only the bucket crane dock is a stable structure and the rest consists of pilings and a floating walkway which rises and falls with the variation of water level. Men must walk on this floating path to attach the barge towing cables and this path must be lighted. Usually this entire area can be properly illuminated by floodlights. Floodlights mounted on an adjacent structure may be directed down onto the barge. If unloading docks extend out and away from nearby structures, floodlights can be mounted on poles or towers especially erected for the purpose. Special care should be taken in lighting docks and unloading areas to preclude damage to the luminaires and supporting members by moving cranes. When a concentration of light is needed for an operation inside a barge, properly beamed floodlights are efficient tools. Any type of luminaire used in these unloading areas should be shielded or positioned so that it will not cause

Figure 8. (below) Floodlighted building entrance.

Figure 9. (right) Floodlighting for barge unloading.

objectionable glare nor confusion to waterway traffic. It is equally important to avoid the possibility of a worker or machine operator being momentarily blinded by glare from a floodlight at some critical instant of operation.

(b) Coal delivered by railroad is often unloaded by car dumpers. This is a device which turns the entire car over and dumps the coal into a pit from which it is removed by conveyor belts. The car dumper area should be well lighted by luminaires suitably positioned to avoid glare in the eyes of the car dumper operator who is usually seated within a building. Light must be provided from such angles that the inside of the car can be seen when it is turned almost upside down so the operator can determine whether all the coal has been dropped. Fig. 10 illustrates a typical car dumper lighted for night-time operation. If cars are emptied from the normal position, illumination must be provided for the operators to safely unfasten the coal chute doors underneath the cars. Lighting in this area usually requires a combination of bracket supported lighting units and floodlights or reflectorized lamps properly located to meet the variety of needs. If the unloading operation is performed inside of a building, or at least in a confining shelter, luminaires for the application must be dust tight or vapor proof. (See latest National Electrical Code.)

Figure 10. Lighting of dumper.

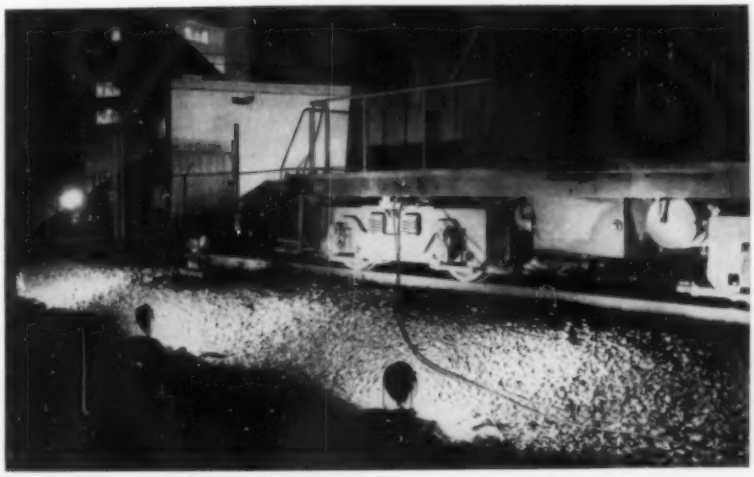


Figure 11. Floodlighting for car inspection.

Figure 12. Coal conveyor belt and storage area lighting.

Figure 13. Pole-mounted lighting of gas delivery and metering point.

In locations where cold weather is experienced, thaw sheds are often used in conjunction with those unloading operations. The thawing is usually done by applying steam directly into the coal or by heating the sides of the cars by some type of flame heat. Lighting must be sufficient and so positioned that steam hose, compressed air hose or torch fuel line connections can be made safely and securely. Fig. 11 illustrates a method of lighting for car inspection.

(c) Coal delivered by truck or conveyor may be dumped into a pit from which it is removed by belt to a storage area, into a hopper or directly onto a storage area. See Fig. 12. These operations require no other special considerations than those covered for the areas mentioned.

3.2.1.2 — *Oil* — Oil delivery is made by tanker, motor truck, railway tank car or pipe lines. Again, lighting methods are similar to those described for barge unloading. In this case the important places to light are the piping connections. Floodlights should be so located with respect to rail sidings so that dense or confusing shadows are not thrown into the working areas.

3.2.1.3 — *Gas* — Gas is delivered through piping which is usually underground. At the metering point the piping emerges and is passed through headers and valves. See Fig. 13. The exterior area requires general illumination which may be provided with floodlights or yard lighting luminaires mounted on poles. The meters are usually located in a small building adjacent to the area. Lighting in the metering house should be of the explosion proof type.

3.2.2 — *Coal Storage Areas* — **(a)** Coal storage piles sometimes contain more than a million tons of coal which may be spread over a large area. Smaller plants will require proportionately smaller storage areas. In this case the coal is more usually stored in conical piles up to 50 feet in depth at the axis. Coal used in power plants, in general, has no specular qualities and is a poor reflector of light. This characteristic creates a different lighting problem.

(b) When coal storage areas are comparatively small and the coal is stored in conical piles, no leveling operations are performed on the tops of the piles. Therefore, it is usually sufficient to light only the perimeter of the storage area. This is done with a system of pole mounted street lighting luminaires. Light distribution characteristics of the luminaires are ordinarily asymmetric.

Figure 14. Floodlighting a coal storage area.

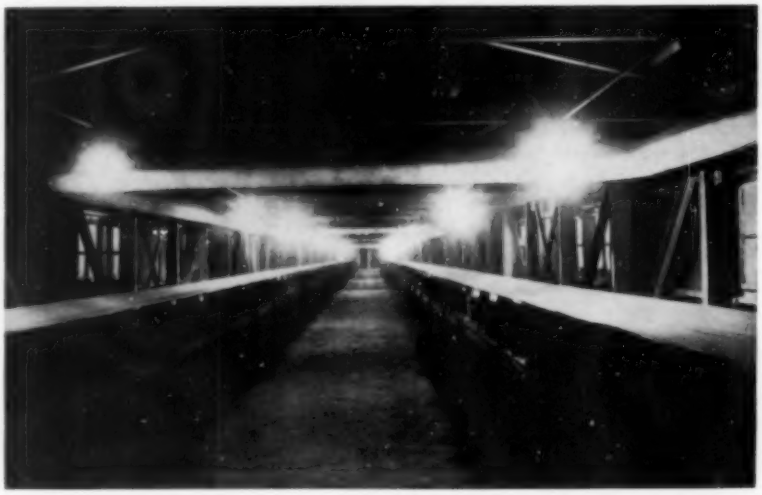


Figure 15. Enclosed coal conveyor lighted with dust-tight luminaires.

(c) When coal storage piles are very large it is usually convenient to keep a record of approximate volume on hand by maintaining the top of the pile level to a constant depth. This is done by motorized equipment or a swinging boom type of structure. Such equipment or structure may be situated on the side of the coal area or in the center and may be connected directly to the plant by conveyor belts (Fig. 12). In such large areas it is the most usual practice to light the coal area by a series of floodlights mounted on high poles or towers or on any other suitable structures available in the area. The beam width and symmetry of distribution is so selected to cover the operating areas. Cross lighting is desirable and often necessary to eliminate objectionable shadows (Fig. 14). It is also the usual practice to mount spotlights on the bulldozers when they are used.

3.2.3 — *Coal Conveyors* — **(a)** Coal conveyors for modern power plants may vary in length from less than 100 feet to as much as several miles. The lighting problem involves the selection of suitable luminaires to provide the required illumination on the coal conveyor belts and associated walkways.

(b) Although coal conveyors are usually covered and sometimes com-

pletely enclosed, parts of these systems may not be so sheltered. The selection of luminaires for these applications will vary, but in general, enclosed moving belts require the use of dust-tight luminaires (see National Electrical Code) having suitable distribution characteristics to direct the light over the belts and on the walkways. See Figs. 15 and 16.

(c) When no overhead shelter is provided along the conveyor line, post-top wide spread asymmetric luminaires which direct the light along the catwalk and belt or tube area, are often found to be satisfactory. See Fig. 17.

3.2.4 — *Oil Storage Tanks* — It is sometimes the practice to fence off oil storage tank areas and to rely on the fence to support luminaires for general area lighting. If properly placed above a tank the same luminaire will furnish light for the inspection of the oil level in the tank. Supplementary lighting may be required for areas under the tanks where valves are located or hose connections are made. Emergency valves may be highlighted by smaller vapor proof luminaires mounted close to them. Such structures as catwalks across a moat, catwalks between tanks, and stairways to the tops of tanks always should be sufficiently lighted.

3.2.5 — *Cooling Towers* — Cooling towers, frequently constructed of wood, carry a number of induced draft fans on the roof which is also the operating deck. The operation of these fans plus the continuous fall of great volumes of water causes severe vibration. The water may be strongly alkaline with a pH as high as 9.0. The air is drawn through the sides of the tower cooling the water through evaporation and is discharged at the roof. This moisture-laden air is highly corrosive. The combination of vibration and corrosion requires floodlighting of the tower if the cost of maintenance is to be kept low. Floodlights should be mounted on poles or towers well removed from the cooling tower (Figs. 18 and 18a).

3.2.6 — *Switch and Transformer Yards —Substations*

3.2.6.1 — *General* — **(a)** Substations contain electrical equipment connected so as to receive electrical energy and distribute it at the same or different voltages When adjacent to a generating station they are often called switchyards or transformer yards, and when separated from the generating station property, to form a junction between the transmission system and the subtransmission system or the distribution system, they may be designated as switching stations. Wherever located, the electrical energy for the district or area they serve passes through and must be switched by their equipment and, as the continuity of the service they provide depends on the speed and accuracy of operating procedures, such as the opening and closing of disconnecting switches, sometimes in inclement weather and frequently with no advanced notice, adequate illumination is of prime importance.

(b) Substations at the generating plant property will usually be large and will contain large transformers and circuit breakers. Substations at other locations on the system may be large or small, attended or unattended and are usually fenced.

(c) In some cases, a more special type of substation may be used which is generally known by such designations as unit type or metal clad substation. These sometimes are not fenced, and in residential areas are screened by appropriate shrubbery. These types of substations present special lighting problems.

3.2.6.2 — *Conventional Substations* — **(a)** In general, the lighting of conven-

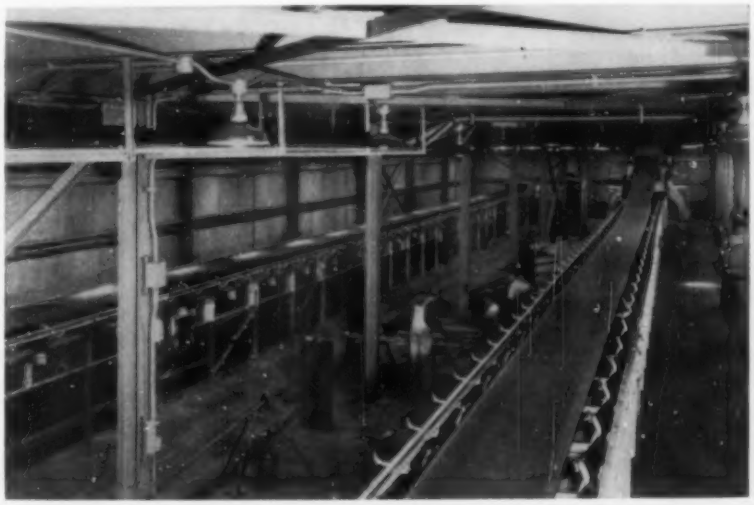


Figure 16. Enclosed coal conveyor lighted with dust-tight luminaires.

Figure 17. Outdoor coal conveyor lighted by wide-spread asymmetric luminaires mounted on posts.

Figure 18. Floodlighting of cooling tower.

tional substations consists of illuminating such electrical equipment as disconnect switches, airbreak switches, high voltage fuses, etc., which are mounted in the structure relatively high above the ground. Stick-operated disconnecting switches are opened and closed by a switch stick, varying in length from five to twelve feet or more and it is necessary for the operator to insert the hook on the end of the stick in an eye of only two or three inches in diameter. It is also necessary to provide general illumination around the station yard in order to allow per-

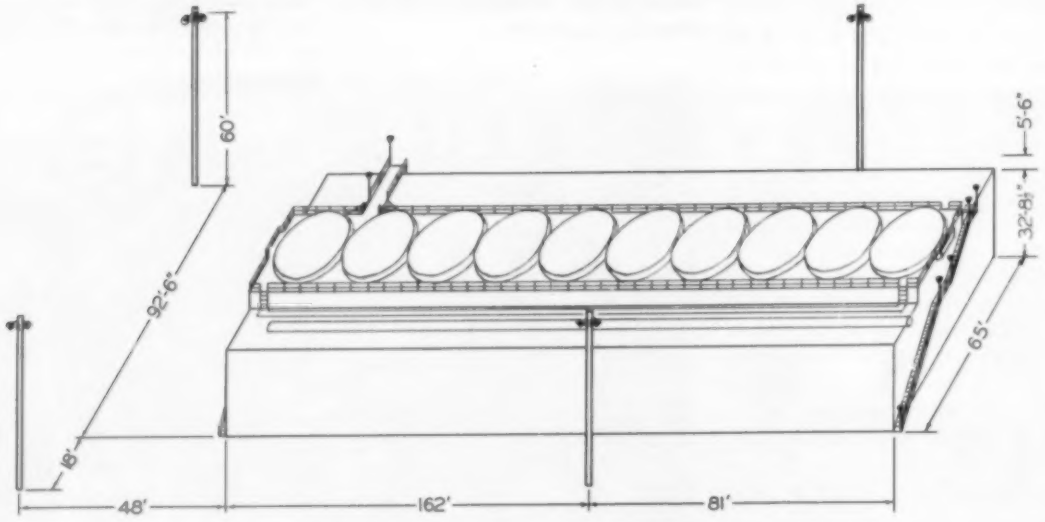


Figure 18a. Floodlighting design of cooling tower.

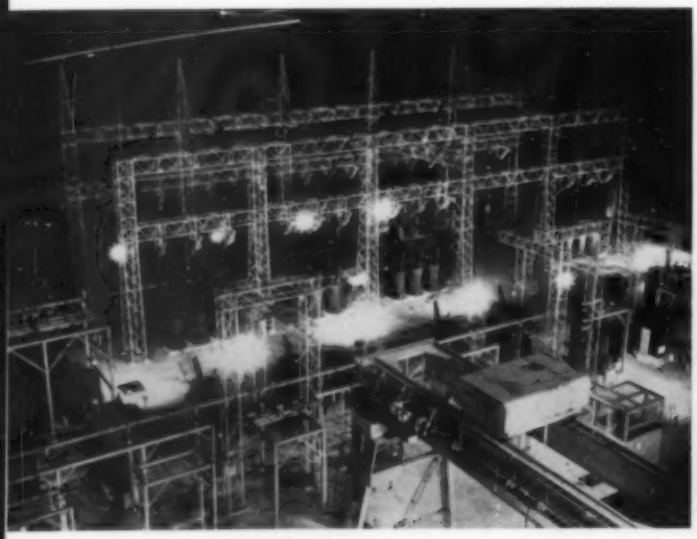


Figure 19. Floodlighting of substation.

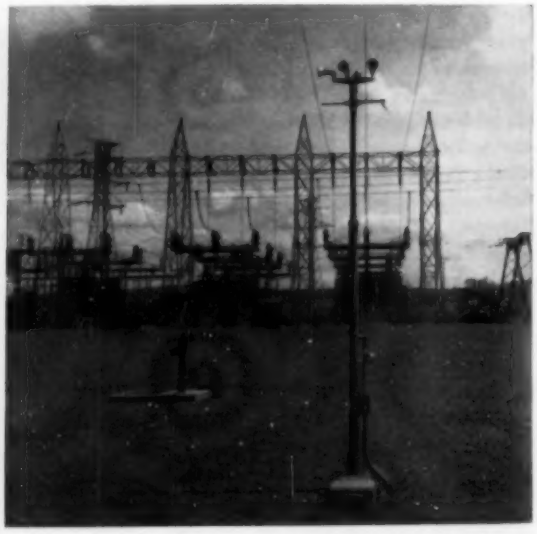


Figure 20. Daytime view of substation lighted by pole-mounted reflector lamps.

sonnel to walk safely about the yard and to see miscellaneous devices and indicators nearer the ground level.

(b) As indicated above, these stations are usually fenced and fence lighting is often provided. The general considerations on fence lighting should be used in design so that light is not directed into windows of private homes or interferes with motorists or pedestrians outside of station property.

(c) A lighting system should have the following features:

(1) It should provide a high component of light directed at the vital elements of the structure.

(2) The system should not produce glare in those zones normally used by operators to observe the vital equipment throughout the yard.

(3) The luminaires utilized should be accessible for relamping and not be placed so close to energized electrical equipment as to present a hazard to those responsible for maintenance.

(4) Sharp shadows should be reduced to a minimum.

(d) Luminaires available for substation lighting include bracket-mounted, post-mounted, floodlights, spotlights, and reflectorized lamps. A few special designs have evolved to provide high upward components for the illumination of the equipment mounted on the superstructure. See Figs. 19 through 23.

3.2.6.3—*Unit Type Substation*—Substations of the unit type are usually

Figure 21. Substation lighted with bracket-mounted substation luminaires.

Figure 22. Daytime view of substation lighting luminaires mounted on brackets attached to structure.

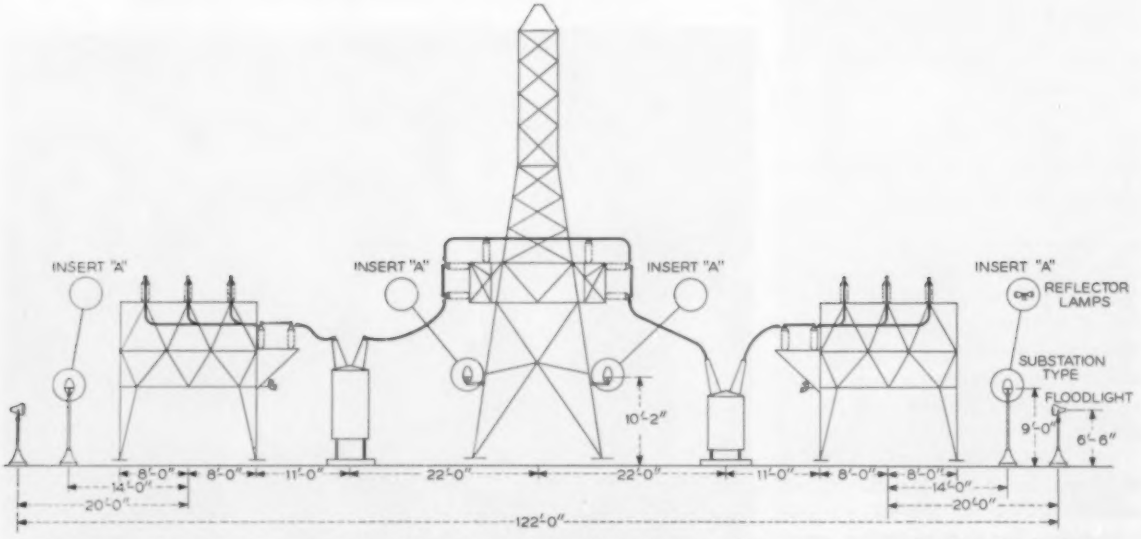


Figure 23. Cross-section of typical substation showing lighting by one of three systems: substation luminaires, floodlights or reflector lamps.

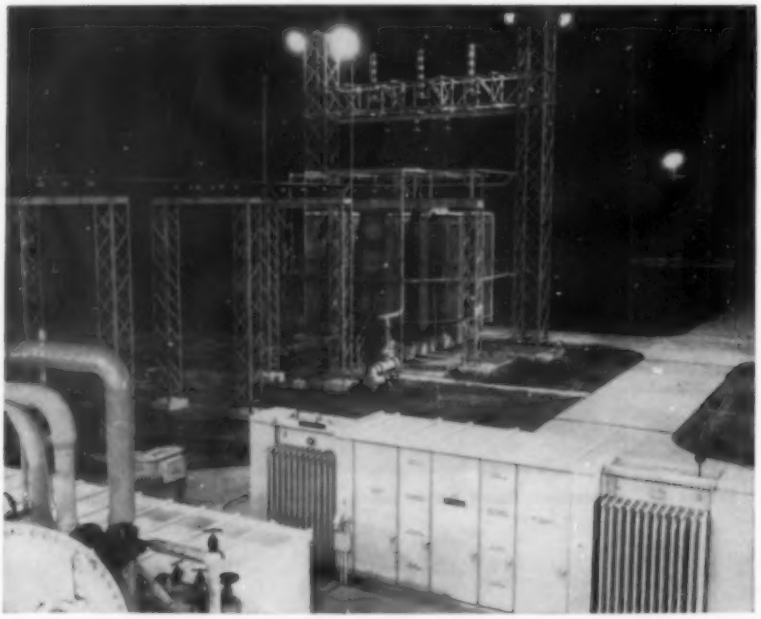


Figure 24. Floodlighted unit type substation.

not fenced but may be landscaped. For this reason it is recommended that more illumination be provided than would be necessary if the property were fenced. See Fig. 24.

3.2.7 — *Outdoor Generating Station* —

(a) The outdoor generating station differs from the conventional generating station in that facilities normally in interior locations are exposed to the weather in some degree. This degree may vary from partial exposure of the boilers to exposure of all facilities except control room and battery room.

(b) Interior areas are illuminated in the same manner as for the conventional station.

(c) The great contrast between light sources and the night sky or unlighted structures may result in conditions of glare not ordinarily considered a problem. Such contrasts may cause an area to appear much more highly illuminated than, in fact, is the case.

(d) In general the exterior areas are lighted with weatherproof equipment. The weatherproof requirement plus low temperature operation during the winter months make the incandescent lamp the most economical and reliable source.

(e) Smaller areas such as boiler platforms, boiler feed pumps, etc., are usually lighted by general purpose luminaires. The lack of ceiling structure often requires the use of bracket or post top types of luminaires. Figs. 25 to 28 illustrate applications of this type of outdoor lighting.

(f) Structures such as turbine decks, heater decks, switchgear and other open areas are best lighted by means of floodlights mounted on the boiler structure. These floodlights may be supplemented by other luminaires where required.

(g) The turbo-generator area beneath the crane requires additional illumination during maintenance periods. Luminaires may be mounted on the underside of the overhead crane structure, or on the crane supporting structure. See Fig. 29.

4. Factors Controlling Illumination and Lighting Systems

4.1 — ***General*** — Many factors must be considered in designing outdoor lighting systems, including: types of luminaires, their light distribution characteristics, their ability to withstand the elements, their maintenance and their mounting requirements, light sources that may be used as part of the various luminaires, illumination levels, and proper positioning of luminaires to reduce glare and shadows.

4.2 — ***Luminaires*** — Fig. 30 shows the wide range of lighting equipment which is available, most of which finds some application around a power plant, but none of which is universally adaptable for all purposes. The general types of outdoor luminaires are: (1) floodlights, (2) Fresnel lens luminaires, (3) searchlights, (4) substation luminaires, (5) street lighting luminaires, (6) other types of outdoor luminaires. These luminaires can be enclosed or open. In choosing the type best suited for the purpose at hand, consideration must be given to the pattern of light distribution, any possibility of causing glare under normal conditions, the mechanical construction and conveni-

Figure 25. Floodlighted outdoor turbine deck also showing handrail lighting.

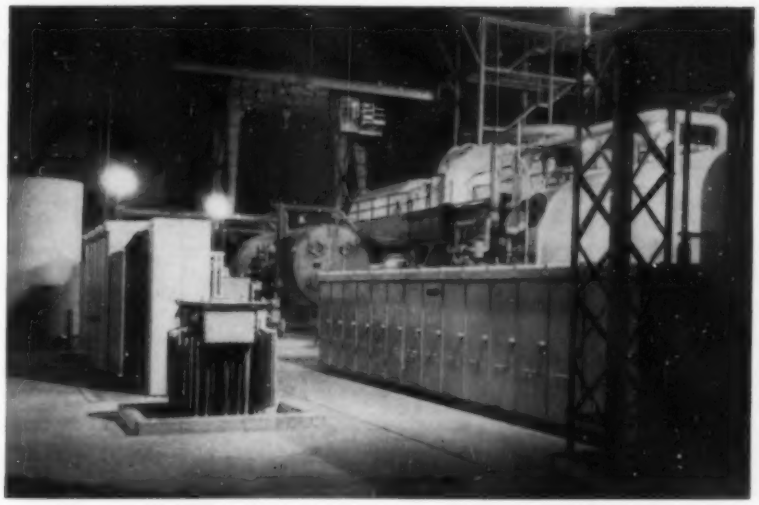


Figure 26. Night view of outdoor generating station showing low-voltage switchgear.

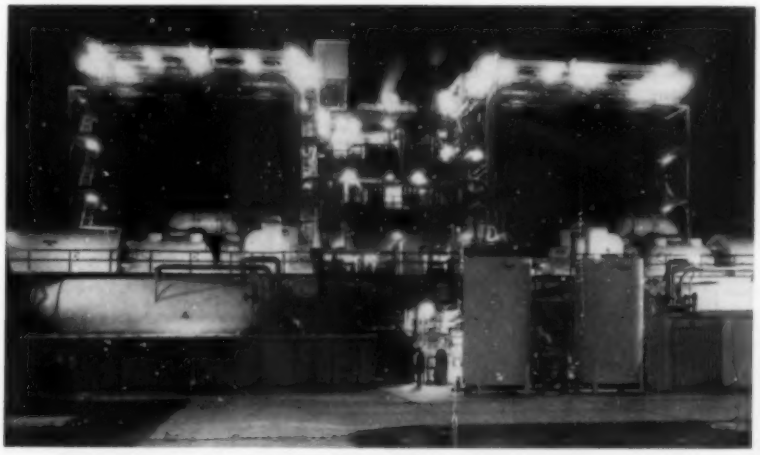


Figure 27. Night view of outdoor generating station.

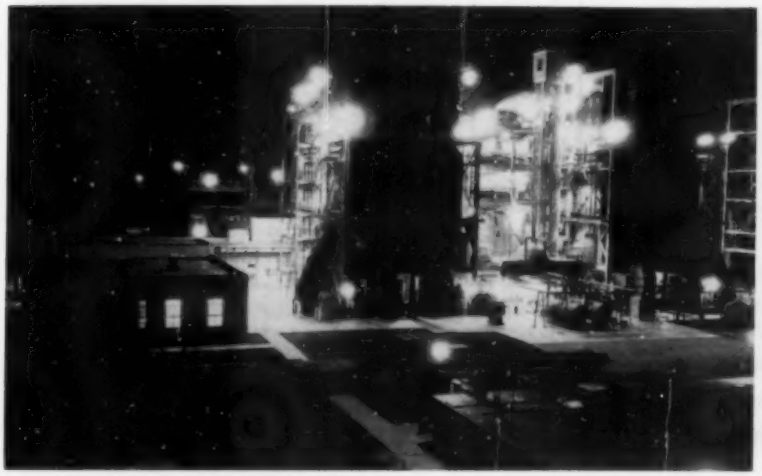
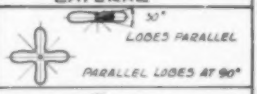
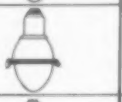
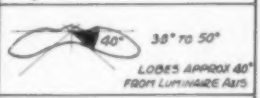
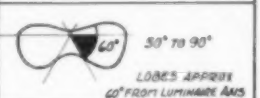
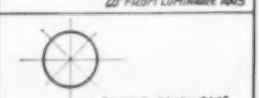
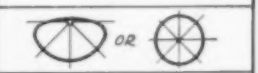
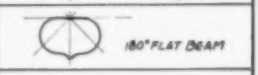
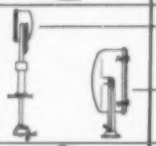
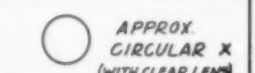
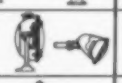
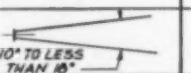
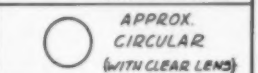
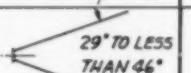
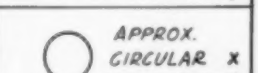
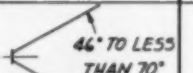
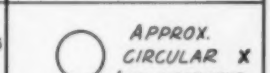
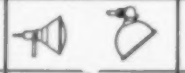
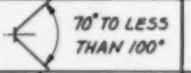
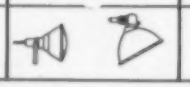
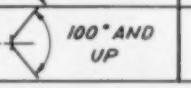
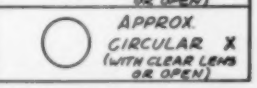


Figure 28. Night view of outdoor generating station from rear.

Figure 29. Daytime view of lighting of turbine deck from crane-mounted luminaires.

TABLE I — Typical Equipment for Outdoor Protective Lighting.

LUMINAIRE		TYPE	PHOTOMETRIC DESIGNATION	OPEN OR ENCLOSED	TYPICAL DISTRIBUTION CHARACTERISTICS	
					VERTICAL	LATERAL
STREETLIGHT		I	TWO-WAY FOUR-WAY	ENCLOSED		
STREETLIGHT		II	NARROW ASYMMETRIC FOUR-WAY	ENCLOSED		
STREETLIGHT		III	MEDIUM WIDE ASYMMETRIC	ENCLOSED		
STREETLIGHT		IV	WIDE ASYMMETRIC	ENCLOSED		
STREETLIGHT		V	SYMMETRIC	ENCLOSED		
REFLECTOR			ASYMMETRIC OR SYMMETRIC	OPEN		
FRESNEL LENS		GLARE PROJECTION	ASYMMETRIC	ENCLOSED		
SEARCHLIGHT			EXTREMELY NARROW BEAM	ENCLOSED		
FLOODLIGHT		1	VERY NARROW BEAM	ENCLOSED		
FLOODLIGHT		2	NARROW BEAM	ENCLOSED		
FLOODLIGHT		3	MEDIUM BEAM	ENCLOSED		
FLOODLIGHT		4	MEDIUM WIDE BEAM	ENCLOSED OR OPEN		
FLOODLIGHT		5	WIDE BEAM	ENCLOSED OR OPEN		
FLOODLIGHT		6	VERY WIDE BEAM	ENCLOSED OR OPEN		

X NOTE: IF A SPREAD LENS IS USED THE VERTICAL SPREAD WILL REMAIN APPROXIMATELY THE SAME, WHILE THE HORIZONTAL BEAM WILL BE WIDENED CONSIDERABLY. ⬭ A CLEAR LENS IS WITHOUT CONTROL MEDIA.

STREET LIGHTING LUMINAIRES ARE TYPICAL ACCORDING TO ASA DESIGNATION.

FLOOD LIGHTING LUMINAIRES ARE TYPICAL ACCORDING TO NEMA AND IES DESIGNATION.

REFLECTORIZED LAMPS FALL INTO FLOODLIGHT CLASSIFICATIONS ACCORDING TO THEIR DISTRIBUTION CHARACTERISTICS

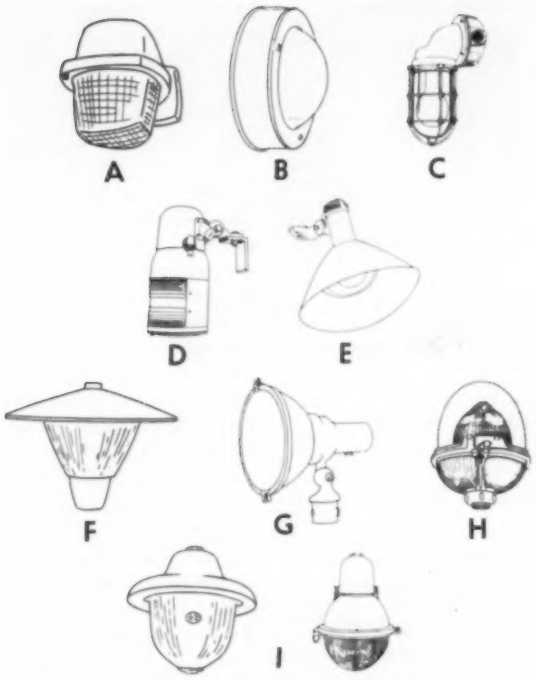


Figure 30. Some types of luminaires suitable for outdoor lighting of central station properties: (A) building-mounted yard lighting unit, (B) pier lighting, (C) wall-mounted vapor-tight unit, (D) Fresnel lens asymmetric unit, (E) floodlight, (F) post-top yard light, (G) searchlight, (H) substation light, (I) street lighting refractors.

ence of servicing, the overall suitability of the unit for the application and its ability to withstand prevalent atmospheric conditions.

4.2.1 — *Floodlights* — **(a)** Floodlights are designed to produce distribution of light flux in definite beam patterns. Floodlights basically are specified in wattages and beam patterns. The latter, expressed in degrees, defines the angle of useful flux included in the beam. (See Table I.)

(b) Floodlights are in general restricted to multiple circuits as they are not suitable for high potential series circuits unless insulating transformers are provided. Enclosed floodlights protect the lamps against damage from rain and also the reflecting surfaces and lamps from the deteriorating effect of the atmosphere.

(c) The beam pattern required will depend upon the area to be covered, the angle at which the beam strikes the area, and the distance of the floodlight from the area. Beam pattern is determined by the contour and finish of the reflector and the type of lamp used, and may be further modified in the case of enclosed floodlights by the type of lens with which it is equipped. Care should be exercised to correctly apply the floodlight, to insure adequate coverage of the area to be lighted and to avoid glare.

(d) Reflectorized lamps in which the reflecting surface is an integral part of the inside of the enclosing bulb of an incandescent or mercury lamp also find applications if these lamps are installed in suitable housings.

4.2.2 — *Fresnel Lens Luminaires* — The Fresnel lens luminaire delivers a fan-shaped beam of light up to 360 degrees in the horizontal plane and from 15-30 degrees in the vertical plane. One application is protective lighting. Its application is limited to locations where advantage may be taken of its unique characteristics without without glare to neighboring activities.

4.2.3 — *Searchlights* — Searchlights are employed mainly to supplement protective lighting systems and for obstruction lighting. (See American Standard Practice for Protective Lighting.)

4.2.4 — *Substation Luminaires* — Substation luminaires are designed to project maximum distribution of light flux upward. They are available with symmetric and asymmetric distribution to meet specific applications related to the physical design of substations and switchyards. For example, the symmetric distribution finds application in large areas where luminaires are located centrally with respect to the operating equipment. The asymmetric distribution is applied where positions or locations of luminaires are restricted to a non-central location.

4.2.5 — *Street Lighting Luminaires* — **(a)** Luminaires are rated by the size of lamp and the characteristics of the light distribution. Luminaires in this classification may be operated from series or multiple circuits.

(b) The distribution of light may be symmetric or asymmetric. A symmetric distribution is one in which the distribution of light and candlepower values are approximately the same in any lateral plane passing through the axis of the luminaire. (See Table I.) Such a distribution of light finds application in lighting large areas where the luminaires may be located centrally with respect to the area to be lighted.

(c) The asymmetric distribution (Table I) may take one of many forms. This type luminaire should be mounted rigidly to prevent rotation. Its purpose is to provide a high utilization of the light by directing it by reflection, refraction, or both into specifically useful directions. The asymmetric distribution finds application in situations where the position or location of the luminaire is restricted with respect to the area to be lighted. Examples of the use of the asymmetric distribution are for lighting disconnect switches in substations, for protective lighting of boundaries where it is advisable to locate the luminaire inside the property and still deliver the light largely outside the property, and for roadways where the pole, of necessity, must be placed outside the limits of the roadway but where the effective light must be directed to the road surface.

4.2.6 — *Other Outdoor Luminaires* — **(a)** The wide variety of outdoor luminaires available for application around power generating stations includes virtually every type in regard to (1) mounting method, (2) totally enclosed or open design, and (3) choice of illuminant. These outdoor luminaires may

TABLE II — Conservative Recommended Levels of Illumination.

	Footcandles
Catwalks	2.0
Cinder Dumps	0.1
Coal Unloading	
(a) Dock (Loading or Unloading Zone)	5.0
(b) Barge Storage Area	0.5
(c) Car Dumper	0.5**
(d) Tipple	5.0
Coal Storage Area	0.1
Conveyors	2.0
Entrances	
Generating or Service Building	
(a) Main	10.0
(b) Secondary	2.0
Gate House	
(a) Pedestrian Entrance	10.0
(b) Conveyance Entrance	5.0**
Fence	0.2
Fuel Oil Delivery Headers	5.0
Oil Storage Tanks	1.0
Open Yard	0.2
Outdoor Storage	1.0
Parking Lot	1.0
Platforms	5.0
Protective Lighting	*
Roadway	
(a) Between or Along Buildings	1.0
(b) Not Bordered by Buildings	0.5
Substation	
(a) General Horizontal	2.0
(b) Specific Vertical (on disconnects)	2.0

*See *IES Lighting Handbook* and American "Standard Practice for Protective Lighting."
**Plus supplementary lighting.
NOTE: For comparative purposes, full moon light produces 0.025 footcandle. Star light (clear moonless night) produces 0.0002 footcandle.

be types designed for outlet box, pendent, wall or post-top mounting. Units are available for multiple or series circuits and with symmetric or asymmetric distributions of light flux.

(b) The selection of outdoor luminaires depends upon a number of factors related to power generating station designs and, to some degree, their locations. Types of structures and their proximity to the area to be lighted as well as the prevailing atmospheric conditions will furnish guides in the selection of suitable outdoor luminaires. For example, an outdoor coal conveyor for a station located at seaboard would require a totally enclosed luminaire having metal parts capable of withstanding salt water corrosion, while a conveyor for a station located inland could be served in a practical manner with an entirely different luminaire.

4.3 — *Light Sources* — **(a)** The incandescent lamp because of its simplicity, dependability, and range of types and sizes is the most commonly used light source in these applications.

(b) For reflectorized lamps see Section 4.2.1 (d).

(c) Mercury lamps, plain and color modified are also used. These lamps are subject to delayed starting and several minutes elapse before full output is obtained.

(d) Fluorescent lamps may be used provided the luminaire and lamp are designed for outdoor operations..

4.4 — *Electrical Distribution and Control*

4.4.1 — *General* — **(a)** Outdoor lighting systems sometimes cover a wide area. Especially in these instances, it is very desirable to give proper consideration to the type of circuits to be used, their construction, their control, and the possibility of duplicate circuits and supply being required.

(b) Electrical distribution circuits for outdoor lighting can be either the multiple or series type. In the former, the lamps used are of the constant voltage type connected in parallel with each other. In the case of the series circuits, the lamps are of the constant-current type connected in series with each other along a single wire loop circuit.

4.4.2 — *Multiple System* — The principal advantage of a multiple system is that it uses the same kind of lamps and other associated equipment as are normally used for building lighting, and with which plant electrical and maintenance men are already familiar.

4.4.3 — *Series System* — The principal advantage of the series lighting system is the saving in conductors that is realized over the multiple system for long circuits Series lighting is especially adaptable in some protective lighting and large area boundary lighting schemes using street lighting types of luminaires, and where considerable distances along the boundaries are involved. Constant-current transformers are required to supply series circuits.

4.4.4 — *Control Methods* — Normal control of an outdoor lighting system may be either manual or automatic and should be independent of the interior lighting system, especially when used for protective lighting purposes. Both manual and automatic schemes are adaptable to remote control of the actual lighting circuits.

4.4.5 — *Duplicate Circuits and Supply* — **(a)** In order to improve reliability of service, it is possible to provide two or more circuits running along together so that every other light may be served from different circuits. This is applicable to both series and multiple circuits and especially desirable for protective lighting applications.

(b) It is also possible and many times desirable to provide automatic throw-over switches to transfer lighting systems from the normal source of power to a duplicate source or an auxiliary source during emergencies.

4.4.6 — *Construction* — Construction of outdoor lighting circuits and supports should be in accordance with good modern practice and in accordance with national and local codes covering construction and operation. Consideration should be given to prevailing weather conditions, local hazards, required operating headroom and clearances, and ease of maintenance.

4.5 — *Illumination Levels* — The illumination levels specified in Table II are based on the study of current satisfactory practice. The values recommended are conservative. It is to be expected that the quantity of illumination will often vary widely and that average footcandle readings are not a true indication of the quality of the installation.

LIGHTING NEWS

Second Street Tree and Utility Conference To Be Held March 7-8 in Cleveland

As part of a long-range program to harmonize installations of street trees and street-side public services, a second Street Tree and Utility Conference will be held in Cleveland on March 7 and 8. Conference Co-Chairmen and the sponsoring organiaztions represented are: John W. Anderson 3d, Edison Electric Institute; Kirk M. Reid, I.E.S.; Edward H. Scanlon, National Shade Tree Conference.

Tentative program is:

March 7 — Morning

Chairman — John W. Anderson
Trees and Utilities — Vital Components in Community Development — Harry T. Sealy, Vice President, Cleveland Electric Illuminating Co., Cleveland, Ohio.
Keynote — Summary of First Conference — Professor H. O. Perkins, University of Connecticut, Storrs, Conn.
Progress Since the First Conference — Case Histories: California, Cleveland, Connecticut, Detroit, Philadelphia.

March 7 — Afternoon

Chairman — Kirk M. Reid
Theme — Trees in Our Communities
The City Planner Looks at Long-Range Street Design — A. R. Schoenfeld, Cleveland, Ohio — American Institute of Planners.
Design Principles of Tree Use to Fit Space and Environment — Markley Stevenson, Philadelphia, Pa. — American Society of Landscape Architects.
Value of Effective Tree Use in Home Building — E. R. Carr, Washington, D. C. — National Association of Home Builders.
Arborists Can Help Achieve Understanding and Co-operation — M. L. Davey, Jr., Kent, Ohio.
Dinner — E. H. Scanlon, Chairman
Teamwork in Public Service — Address, Speaker to be announced.

March 8 — Morning

Chairman — Edward H. Scanlon
Theme — The Long-Range Street Tree Program
Why We Need a Street Tree Program — Stephen T. Zona, Mayor, Parma, Ohio.
Street Tree Programs in Operation — John Michalko, Commissioner of Shade Trees, Cleveland, Ohio.
Robert B. Henn, Superintendent of Parks, Euclid, Ohio.
Leonard F. Anderson, Secretary, Shade Tree Commission, Essex County, N. J.
Selection and Propagation of Functional and Ornamental Trees — Henry T. Skinner, Director, National Arboretum, Washington, D. C.
Practical Aspects of Marketing Street Trees — James I. E. Ilgenfritz, Monroe, Mich.

March 8 — Afternoon

Chairman — Kirk M. Reid
Forum — Panel of all speakers.
Questions and Discussions.
Conference Summary — And the Next Steps — Professor H. O. Perkins.

The registration fee of $12.50 includes the banquet and a copy of Conference Proceedings, in which all papers and discussions will be printed following the Conference. Registrations, with registration fee, should be sent to E. H. Scanlon, 7621 Lewis Rd., Olmsted Falls, Ohio. Hotel reservations should be made directly with the Hotel Cleveland, mentioning attendance at the Street Tree and Utility Conference.

Action Conference Stresses Need For Highway Night Safety

Speakers at an emergency traffic safety conference, held January 15 at the Waldorf-Astoria, New York City, stressed the toll that traffic accidents cost, in both life, property and damages, urged the importance of adequate lighting to curb accidents, and announced the installation by the State of Connecticut of an expanded program of turnpike lighting.

Entitled the Action Conference for Night Safety on the Highways, the meeting was sponsored by the Street and Highway Safety Lighting Bureau and was under the direction of Edmond C. Powers. It was the occasion for the announcement by Commissioner Newman E. Argraves of the Connecticut State Highway Department that the State was installing a lighting system on 53 continuous miles of the Connecticut Turnpike which would provide illumination levels meeting recommended practice.

Speakers on the program and their topics are:

Greeting from the City of New York — Abe Stark, President of the City Council.
Scope of the Federal Roads Program — Joseph Barnett, Bureau of Public Roads, U. S. Department of Commerce, Washington, D. C.
The Toll of Night Traffic Accidents in Lives and Injuries — George E. Grotz, National Safety Council, Chicago, Ill.
The Bill for Our Traffic Ill — Paul H. Blaisdell, Director, Traffic Safety Division, Association of Casualty and Surety Companies, New York, N. Y.
Engineering Safety into Our Highways — Louis W. Prentiss, Executive Vice President, American Road Builders Association, Washington, D. C.
Announcement by Edmond C. Powers, Education Director, Street and Highway Safety Lighting Bureau.
How the State of Connecticut Is Backing the Attack on Night Accidents — Newman E. Argraves, Commissioner, Connecticut Department of Highways, Hartford, Conn.

ISCC Annual Meeting Scheduled for March 6

The annual meeting of the Inter-Society Color Council will be held at the Statler Hotel, New York City, March 6, a full-day meeting of reports, speakers and evening banquet. The morning session will be given over to reports of subcommittees of the Problems Committee and the annual business meeting.

The afternoon symposium will present the picture of trends in color choice in the fields of plastics, textiles and paint. Speakers are: A. J. Benjamin, Monsanto Chemical Co.; Elschen Hood, Coates and Clark, Inc.; and Everett Call, National Paint, Varnish and Lacquer, Association.

Speaker at the banquet will be George J. Pollard, Jr., Design Supervisor for Styling, General Motor Corp., who will discuss "Color in Product Styling."

Status of Engineers Discussed At Two-Day Meeting

The vital place of the engineers, nationally in defense, internationally on the technological "cold front" and what they should be paid in our expanding economy were three paramount topics at the 1957 Engineers Joint Council General Assembly, January 17 and 18 at the New York Statler Hotel.

The two-day annual meeting heard Major General J. B. Madaris and Dr. Werner von Braun of the United States Ballistic Missile Agency as well as a senior representative of the U. S. Civil

Here and There with I.E.S. Members

Annual joint meeting of the Michigan Section with the Section's Residence Lighting Forum was held December 11 at the Detroit Yacht Club. Members of the American Institute of Architects were invited and attendance was 100. At the head table, left to right are: Mrs. Mariquita Dygert, Mrs. Lloyd Gabler, Lloyd Gabler, Miss Mary Taepke, Harry Robbins and Mrs. Harry Robbins. Miss Taepke (photo at right) was speaker of the evening, substituting with great success for scheduled speaker Miss Katherine Goodall, who became snow-bound en route from Philadelphia. She discussed the lighting in an apartment of a couple whose hobby is electrical devices.

I.E.S. Members, in this case, being those of our sister Society in Japan. Here shown with President Marshall N. Waterman, a delegation from the Japanese I.E.S. was sent in celebration of their 40th Anniversary to the American I.E.S. on our 50th. Mr. Waterman holds the brocaded tapestry, a present from Japan.

Official records of the San Jacinto Section are handed over by Secretary-Treasurer J. F. Dill (left), who has been transferred to Milwaukee, to his appointed successor R. C. Jung. Section Chairman Curt Grevelius (center) supervises the action, which occurred at the Section's December 7th meeting.

Service Commission and an authority on the highway development program.

"The Engineer and the American Economy" was the title of the Thursday luncheon address by Professor John Bell Rae of Case Institute of Technology. This was followed in the afternoon by a panel analysis of the salary structure of engineers. Latest available data on professional income of engineers and the principal methods of salary administration were presented.

The EJC Assembly Dinner on Thursday evening heard Dr. Henry T. Heald, President of the Ford Foundation, as principal speaker.

The relations of the engineer to the international scene and his vital role in the maintenance of the balance of technological power in the world were presented by the Friday panel. At the concluding luncheon the assembly heard W. A. B. Illiff, Vice-President, International Bank for Reconstruction and Development, talk on "Overseas Development, Engineers and the World Bank."

Full-Day Lighting Clinic Presented by New York Section

A morning and afternoon lighting clinic was presented by the New York Section of I.E.S., January 15 at the Polytecnic Institute of Brooklyn, Student Lounge, Brooklyn, N. Y. The program included:

Introduction — Clyde C. Whipple, Professor of Electrical Engineering, Polytechnic Institute of Brooklyn.
Nomenclature — Priscilla Presbrey, Westinghouse Electric Corp., Bloomfield, N. J.
Lighting Calculations — Abraham Abramowitz, Professor of Electrical Engineering, City College of New York.
Incandescent and Fluorescent Sources — Alston Rogers, General Electric Lighting Institute, Cleveland, Ohio.
Mercury Vapor Sources — Eugene W. Beggs, Westinghouse Electric Corp., Bloomfield, N.J.
Photometry — Ernest H. Salter — Electrical Testing Laborstories, New York, N. Y.
Factors Involved in Seeing — H. L. Logan, The Holophane Co., Inc., New York, N. Y.
Application of Lighting Equipment — Willard Allphin, Sylvania Electric Products Inc., Salem, Mass.
The Future of Illuminating Engineering — S. G. Hibben, Illuminating Engineer.

G-E Science Fellowships Offered by Case Institute

For the eleventh consecutive year, Case Institute of Technology will offer fifty all-expense General Electric Science Fellowships to preparatory and high school teachers of physics from the north central states area, for a special six-week study program from June 16 through July 26, 1957.

Members of the Case faculty who will conduct the program are Russell C. Put-

SCHEDULED EVENTS

February 17-20, 1957 — National Electric Sign Association, Annual Convention and Exhibit, Sheraton Park Hotel, Washington, D. C.

February 25-28, 1957 — American Society of Heating and Air-Conditioning Engineers, 63rd Annual Meeting, Chicago, Ill.

February 25 - March 1, 1957 — 13th International Heating and Air-Conditioning Exposition, Chicago, Ill.

February 28-March 1, 1957 — National Adequate Wiring Conference, La Salle Hotel, Chicago, Ill.

March 4-7, 1957 — National Rural Electric Cooperative Associaiton, Conrad Hilton Hotel, Chicago, Ill.

March 5-6, 1957 — Twenty-sixth Annual Meeting, Inter-Society Color Council, Hotel Statler, New York, N. Y.

March 28-29, 1957 — Pacific Northwest Regional Conference, Illuminating Engineering Society, Empress Hotel, Victoria, B. C.

April 3-5, 1957 — South Pacific Coast Regional Conference, Illuminating Engineering Society, Hotel Statler, Los Angeles, Calif.

April 8-11, 1957 — Fourth National Electrical Industries Show, 71st Regiment Armory, New York, N. Y.

April 11-12, 1957 — Inter-Mountain Regional Conference, Illuminating Engineering Society, Alvarado Hotel, Albuquerque, N. M.

April 14-17, 1957 — Building Research Institute, Drake Hotel, Chicago, Ill.

April 18, 1957 — I.E.S. Council Meeting, New York, N. Y.

April 28-30, 1957 — Southwestern Regional Conference, Illuminating Engineering Society, Holiday Inn, Oklahoma City, Okla.

April 29 - May 3, 1957 — Society of Motion Picture and Television Engineers, Shoreham Hotel, Washington, D. C.

April 30 - May 2, 1957 — National Association of Lighting Maintenance Contractors, Conference, Kansas City, Mo.

May 6-8, 1957 — Air Conditioning and Refrigeration Institute, Annual Meeting. The Homestead, Hot Springs, Va.

May 7-9, 1957 — Chicago Electrical Industry Show, Chicago, Ill.

May 9-10, 1957 — Midwestern Regional Conference, Illuminating Engineering Society, Hotel Pfister, Milwaukee, Wis.

May 13-14, 1957 — Great Lakes Regional Conference, Illuminating Engineering Society, Pantlind Hotel, Grand Rapids, Mich.

May 15-17, 1957 — Pacific Coast Electrical Association, Inc., Annual Convention, Fairmont Hotel, San Francisco, Calif.

May 16-17, 1957 — Canadian Regional Conference, Illuminating Engineering Society, Hotel Sheraton Brock, Niagara Falls, Ont.

May 20-24, 1957 — National Fire Protection Association, Annual Meeting, Statler Hotel, Los Angeles, Calif.

May 23-24, 1957 — East Central Regional Conference, Illuminating Engineering Society, William Penn Hotel, Pittsburgh, Pa.

May 26-29, 1957 — National Association of Electrical Distributors, Sheraton-Park and Shoreham Hotels, Washington, D. C.

June 4-6, 1957 — Chicago Electrical Industry Show, Conrad Hilton Hotel, Chicago, Ill.

June 12, 1957 — I.E.S. Council Meeting, New York, N. Y.

June 13-14, 1957 — Northeastern Regional Conference, Illuminating Engineering Society, Hotel Statler, New York, N. Y.

June 24-27, 1957 — American Society of Heating and Air-Conditioning Engineers, Murray Bay, Quebec, Que.

June 24-28, 1957 — American Institute of Electrical Engineers, Summer General Meeting Montreal, Que.

August 28-30, 1957 — American Institute of Electrical Engineers, Pacific General Meeting Yakima, Wash.

September 9-13, 1957 — Illuminating Engineering Society, National Technical Conference, Biltmore Hotel, Atlanta, Ga.

September 24-26, 1957 — Institute of Traffic Engineers, Statler Hotel, Detroit, Mich.

October 4-9, 1957 — Society of Motion Picture and Television Engineers, Hotel Sheraton, Philadelphia, Pa.

October 7-9, 1957 — National Electronics Conference, Inc., Hotel Sherman, Chicago, Ill.

October 7-11, 1957 — American Institute of Electrical Engineers, Fall General Meeting, Chicago, Ill.

October 9-11, 1957 — Canadian Electrical Manufacturers Associaiton, Sheraton-Brock Hotel, Ningara Falls, Ont.

October 21-25, 1957 — National Safety Council, 45th National Safety Congress & Exposition, Chicago, Ill.

October 27-30, 1957 — National Association of Electrical Distributors (Board of Governors), Skytop Lodge, Skytop, Pa.

November 11-15, 1957 — National Electrical Manufacturers Association, Traymore Hotel, Atlantic City, N. J.

November 18-21, 1957 — 10th Exposition of the Air-Conditioning and Refrigeration Industry, Navy Pier, Chicago, Ill.

I.E.S. National Technical Conferences

1957 — September 9-13 — Biltmore Hotel, Atlanta, Georgia

1958 — August 17-22 — Royal York Hotel, Toronto, Ontario

1959 — September 7-11 — Hotels Fairmont and Mark Hopkins, San Francisco, California

nam, Professor of Electrical Engineering; Dr. Robert S. Shankland; Ambrose Swasey, Professor of Physics and head of the department; Dr. Leonard O. Olsen and Dr. R. L. Sutton, Professors of Physics.

Applications for the 1957 G-E Science Fellowships may be obtained from: Dean Elmer Hutchisson, Case Institute of Technology, 19099 Euclid Ave., Cleveland 6, Ohio.

Lighting Fundamentals Covered In Toronto Course

Eight lectures of 1½ hours each, from January 10 through February 28, are covering the Fundamentals of Lighting, sponsored by the Toronto Section of I.E.S. Classes are being held at the Building Centre, in Toronto. The program and instructors are:

Light and Sight — M. K. Strang, Curtis Lighting of Canada Ltd.
Fundamentals of Illumination — G. E. Davidson, Hydro Electric Power Commission of Ontario
Light Sources I — H. C. Jones, Canadian General Electric Co., Ltd.
Light Sources II — E. I. Morwick, Canadian Westinghouse Co.
Illumination Design — D. F. Davis, Northern Electric Co.
Industrial Application — W. A. Dalrymple, Amalgamated Electric Corp.
Office and School Applications — J. M. Chorlton, Toronto Board of Education
Store Lighting Applications — Norman Bethune, C & M Products, Ltd.

Tuition fee for the course is $8.00, with a refund of $3.00 to all those who attend all lectures.

Residential Interiors — Topic Of New York Forum Series

A six-session course on the principles and current methods of lighting residence, planned for decorators, designers, architects or homemakers, is being sponsored by the Residence Lighting Forum of the New York Section, I.E.S. Sessions are being held, February 18 through March 25, 6:30 to 8:30 p.m., at the General Electric Aduitorium, 570 Lexington Ave., New York City. The topics and lecturers at the sessions are:

February 18 — Lighting Fundamentals — Priscilla Presbrey, Westinghouse Electric Corp.
February 25 — Light Bulbs and Fluorescent Tubes — B. F. Boylan, General Electric Co., and Jan Reynolds, Sylvania Electric Products Inc.
March 4 — Lamps and Fixtures — Lillian Eddy, General Electric Co.
March 11 — Guided Tour through Lightolier Showroom.
March 18 — Lighting Solutions for Specific Seeing Problems and Whole Rooms — Mary Pelkonen, Long Island Lighting Co.
March 25 — Lighting for Decorative Accent — Eve Freyer, Westinghouse Electric Corp.

Registration fee is $5.00 for members of I.E.S. or the Forum, $7.50 to all others.

Dr. E. F. Lowry Dead; I.E.S. Medalist

Dr. E. F. Lowry

Dr. Erwin F. Lowry, a Fellow of I.E.S. and recipient of its highest honor the Gold Medal, died suddenly January 2 in Salem, Mass. He was 65 years old.

An eminent physicist in light source research, Dr. Lowry was especially renowned for his work in cathode research, fluorescent lamp and phosphor developments in electroluminescence. His achievements in these fields won for him the highest award in illumination when, in 1954, he was awarded the Gold Medal of the Illuminating Engineering Society. Dr. Lowry held 30 patents, most of which related to gaseous discharge devices, and especially cathodes. Several others, on fluorescent lamps and in electroluminescence, are now pending.

Dr. Lowry was manager of the research engineering laboratories of the Lighting Division of Sylvania Electric Products Inc., at Salem, Mass., and in this capacity was instrumental in his company's development of their VHO fluorescent lamp. Dr. Lowry also initiated and directed his company's work toward an electroluminescent lamp as a practical device, and was principal speaker at a Sylvania conference on electroluminescence held in New York City in mid-December.

Dr. Lowry joined Sylvania in 1940 as a senior engineer in the fluorescent engineering department of the company's Boston Street, Salem, lighting facility. Progressing through engineering and management posts, he became manager of fluorescent engineering three years later. He was named manager of the research laboratories in 1949.

Prior to his connection with Sylvania, Dr. Lowry had been director of research at Flexolite Company for a year, and, for the preceding three years held the same position with Continental Electric Company. For eleven years, from 1925 to 1936, he was a research engineer with Westinghouse Electric Corp.

A graduate of Ohio Wesleyan University in 1914, Dr. Lowry received an A.M. degree from Ohio Wesleyan in 1916, and a Ph.D. in Physics from Ohio State University in 1923. For eleven years, from 1914 to 1925, he taught physics at Ohio Wesleyan, at the University of Pittsburgh, and at Ohio State University, respectively.

A Fellow of I.E.S. since 1950, Dr. Lowry was active in many of the Society's committees, serving as chairman of the Light Source Committee and the Board of Fellows. At the time of his death he was a member of the Papers Committee, the Editorial Review subcommittee (for I.E.) and the Committee on Light Sources. In addition to his work with I.E.S., he was a member also of the American Physical Society and the Electrochemical Society, where he was a past chairman of the Luminescence Section. He was also a member of the American Institute of Electrical Engineers, the U. S. National Commission on Illumination, and the Societe Francaise de Ingenieurs Techniciens de Vide. He had presented many papers before I.E.S. and other scientific groups.

Yale Traffic Bureau To Increase Training Program

The Bureau of Highway Traffic at Yale University is increasing is training program to help meet the current high demand for engineers trained in street and highway operations. This demand has been produced by the current need for professional traffic engineering services in both urban and rural areas. It has been estimated that over twelve hundred traffic operations engineers are needed throughout the country to help plan and design the new streets and highways to be provided by the National Highway Improvement Program and to relieve traffic congestion on existing streets through the application of regulations and controls.

The Bureau of Highway Traffic has been in operation since 1926. The traffic engineering course is at the graduate level and covers a full academic year wtih classes starting in September and terminating the following May. It is devoted entirely to highway traffic operations and is designed to equip men for responsible positions in this field of work upon graduation. The Bureau has graduated 396 men and 90% of the graduates are actively engaged in traffic engineering work.

(Continued on page 15A)

NEW FROST-WHITE shields can really take a beating. Bend them like this, throw them on the floor or jump on them. They defy destruction. Breakage in shipping and handling is thus minimized.

FIRST BREAK-RESISTANT, REFLECTION-FREE PLASTIC SHIELDS ANNOUNCED BY SHEFFIELD

Now you can cut out unwanted reflections of light from the surfaces of the plastic shields on your fluorescent fixtures. Sheffield's new FROST-WHITE polystyrene shields have a velvety finish which absorbs stray light and prevents eye-straining reflections.

Highly resistant to impact and flexing, the new shields minimize breakage in shipping and handling, cut replacement costs and speed assembly. These properties have been achieved without sacrifice of dimensional stability, heat resistance or cold flow.

FROST-WHITE shields have a bright white color too and light stability superior to that of shields made with regular styrene. Though made with a premium material, their cost is the same as regular shields.

Use the coupon below to get complete technical data on FROST-WHITE shields. See how they can help you improve your present plastic-shielded fixtures and cut costs.

Precision Engineered Rigid Plastic Extrusions

ABSENCE of light reflection from new FROST-WHITE shield (A) is readily seen in comparison to highly reflectant regular polystyrene shield (B). Unlimited possibilities for new fixture designs are thereby created.

FOR MORE INFORMATION

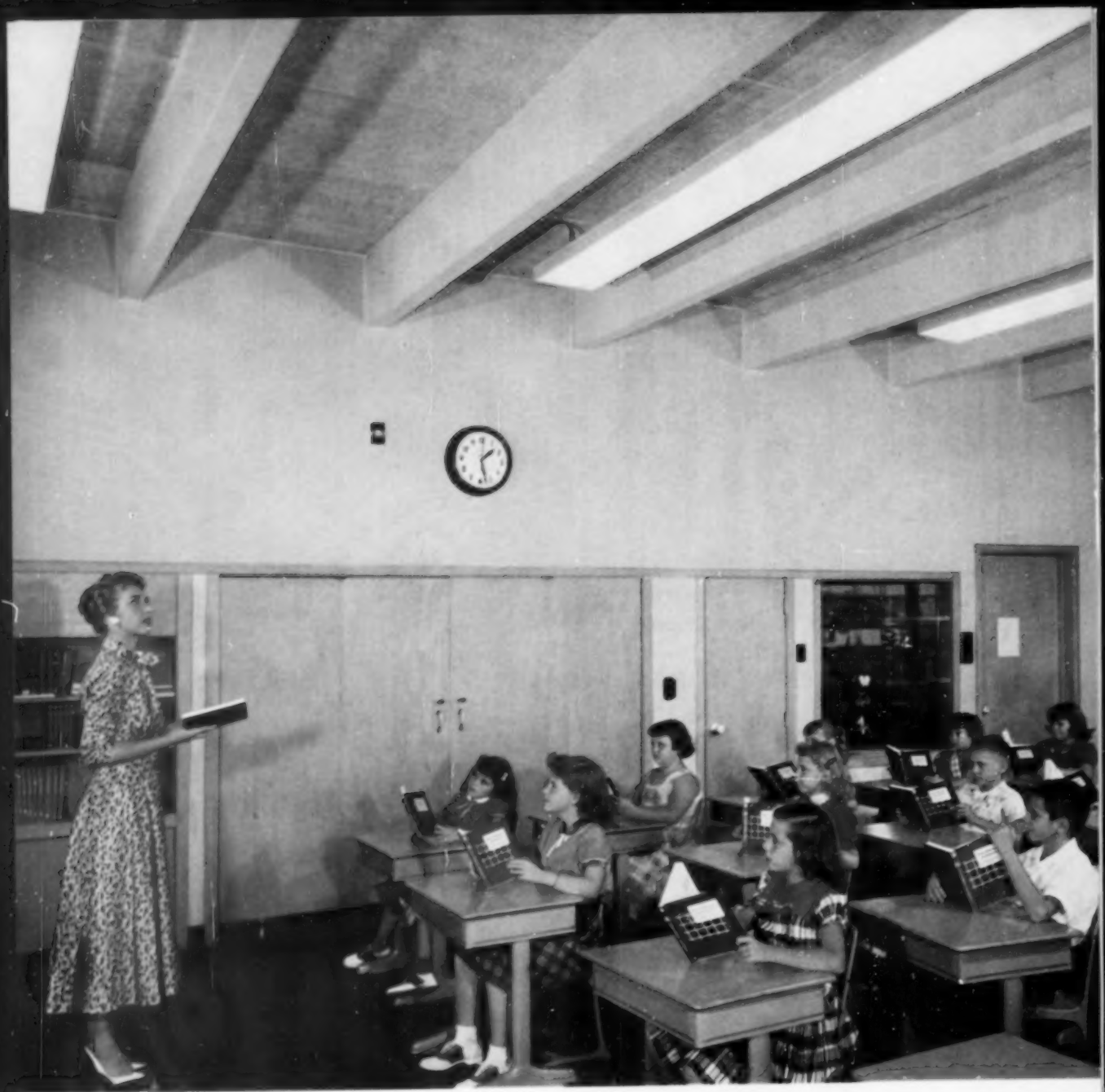
Sheffield Plastics Inc.
Section 71-B
Sheffield, Mass.

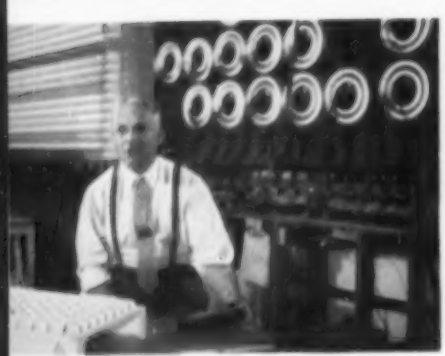
Gentlemen:
Please send me complete data on your new Frost-White shields. I want this information for

- ☐ reference only
- ☐ an immediate application
- ☐ have your representative call

Name ..... Position .....
Company .....
Street .....
City ..... State .....

SHEFFIELD PLASTICS
INC.
SHEFFIELD, MASS.





Fluorescent fixture noise is due to ballast noise, fixture amplification, type of ceiling, etc. G-E ballasts are designed to operate quietly and give you a "Sound Rated" installation every time.

G.E. has designed a three-piece core assembly with push-on clamps. All air gaps are cemented and special coil wedges reduce vibration in the core and coil assembly. A special potting compound aids in noise reduction.

G.E.'s new sound laboratory pays off in quieter ballasts for you. Sound engineers test every new design and spot check production models in an attempt to find new methods and materials to give you a quieter ballast.

Adequate light, yes—But WHAT'S THAT HUMMING?

New General Electric Sound Rating Calculator to aid fixture manufacturers

Many fluorescent lighting installations are furnishing the specified light, but they also are furnishing an unspecified distraction—***noise.***

Every ballast has a normal magnetic hum. However, the intensity of the humming in fixtures is dependent not only upon such factors as basic ballast construction and the ballast rating, but fixture construction and installation can also contribute to a large extent to noise amplification. And, because of these variable factors, fluorescent lighting installations can range all the way from silent to noisy and annoying.

Now specifiers of fluorescent lighting can determine beforehand whether or not they will encounter a ballast noise problem.

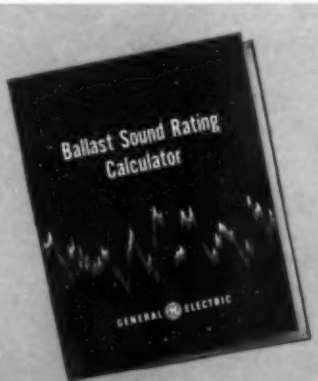
It's done this way: every G-E ballast currently listed has a sound rating. By knowing this rating, the number of ballasts in the installation, the size and acoustical characteristics and ambient sound level of the room, they can determine whether or not a sound problem will be encountered. All they have to do is feed this information into the exclusive new G-E ballast Sound Rating Calculator. It's as simple as that.

You'll want to be sure that your fixtures can be "Sound-rated," therefore, use General Electric ballasts and give your customers a sound-rated installation every time.

Progress Is Our Most Important Product

GENERAL ELECTRIC

On the spot application engineering assistance is also available. Nearly 100 ballast application engineers located throughout the United States stand ready to assist you. They are as close to you as your telephone.



SEND FOR YOUR SOUND RATING CALCULATOR

Send check for one dollar with your name and address to: General Electric Company, Section B401-30, Schenectady 5, N. Y. Your Sound Rating Calculator will be sent to you by return mail.

Meet Litecontrol's

NEW 7300

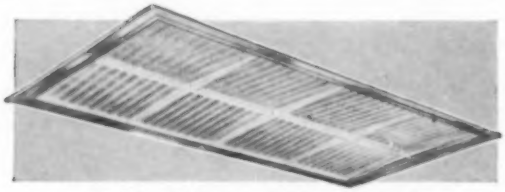
SERIES FIXTURE

. . . *Modern lighting at its Problem-Solving Best with Holophane's New, Revolutionary Acrylic Lens*

Yes, *here is modern surface lighting at its best* for modern stores and offices. Why? Because here is an attractive fixture which utilizes the Holophane No. 6024 Controlens* — the lens that has broken the glare barrier. This lens, extremely high in efficiency while low in brightness, permits the use of high lighting levels without the glare discomfort heretofore unavoidable with high footcandle installations. What's more, the fixture is sturdy, light-in-weight and economical . . . first cost and maintenance are appealing to any budget. If you have a lighting problem, this is the type of standard fixture that can solve it for you. Available with 2, 4, or 6-40 watt rapid start lamps — length 49⅛ inches, height 4¾ inches.

QUICK FACTS

- **TYPE** — Surface hinged acrylic lens fixture
- **HOUSING** — Die-Formed, all welded. Made of at least 20 Gauge Electroplated Zinc Coated Steel, for Rust Prevention and Bonderized for paint adherence.
- **HINGED DOOR** — Easy to open and close with Trigger Catch. 16 gauge die formed steel, welded throughout.
- **SIDE PANELS** — Translucent plastic
- **FINISH** — Baked white enamel
- **KNOCKOUTS and HOLES** in top for easy mounting



Also New! Litecontrol 8300 Series for Recessed Mounting

Like the 7300 Series, the 8300 may be easily used to advantage individually or in rows in stores, offices, auditoriums, banks and elsewhere. It is designed for recessed mounting in plaster or T-Bar ceiling (will not snap in). Not for inverted Tee grid ceilings (for which other designs will be available). 2, 3, 4 or 6-40 watt rapid start lamps. Holophane No. 6025 CONTROLENS*. Hinged door is removable, opens from either side, Trigger Catch. Length 48 inches, height 7 inches. Other construction details similar to 7300 Series.

*Registered T.M.

LITECONTROL

Fixtures

KEEP UPKEEP DOWN

LITECONTROL CORPORATION

36 Pleasant Street, Watertown 72, Massachusetts

DESIGNERS, ENGINEERS AND MANUFACTURERS OF FLUORESCENT LIGHTING EQUIPMENT DISTRIBUTED ONLY THROUGH ACCREDITED WHOLESALERS

(Continued from page 10A)

The academic year of study offered by the Bureau consists of two full semesters of classroom work, laboratory and individual research, required reading, field problems and seminars. The courses include (1) traffic characteristics and measuremetns, (2) traffic regulations and control devices, (3) traffic facility planning and design, and (4) highway administration and finance.

Next year the Bureau will offer a number of fellowships to citizens of the United States who are qualified for graduate work. All the fellowships provide a living stipend of $1,400 disbursed at the rate of $175 per month for a period of eight months. The fellowships also provide the tuition fee of $600. They are made available to the Bureau through grants from the Automotive Safety Foundation, The Esso Safety Foundation, The Liberty Mutual Insurance Co. and The James S. Kemper Foundation. The International Road Educational Foundation provides financial aid to a limited number of foreign students. The Bureau also offers tuition scholarships to qualified municipal and state highway engineers.

Information on admission and fellowships may be obtained from Fred W. Hurd, Director, Bureau of Highway Traffic, Yale University, Strathcona Hall, New Haven, Conn.

Milwaukee Section Sponsors Commercial/Industrial Course

In cooperation with the Wisconsin Electric Power Co., the Milwaukee Section of I.E.S. sponsored, last Fall and early Winter a Commercial and Industrial Fundamental Lighting Course, designed for architects and electrical contractors. The course was offered as part of the Section's commemoration of the I.E.S. Golden Anniversary.

Originally planned for an enrollment of 50, the course expanded to provide for 78 registrants, 62 of whom completed the series of classes to obtain a certificate. All classes were held at the Engineers Society Building and each two-hour session was conducted by two speakers. The first speaker covered the lighting design and the second showed the application of lighting by means of colored slides. Fourteen I.E.S. members served as instructors. I. L. Illing was Master of Ceremonies.

Program and speakers were:

October 22 — New Development in Light Sources — Ralph Cheney and William Kennedy
October 29 — Lighting Design Methods — I. L. Illing and Robert VandenBoom
November 5 — Lighting for Merchandising — E. H. Schaefer and Martin Weiss
November 12 — Office Lighting Design — C. N. Laupp and Gordon Petzold
November 19 — School Lighting Techniques — T. D. Dustin and C. N. Laupp
November 26 — Church and Public Building Lighting — I. L. Illing and A. B. Bowold
Decemger 3 — Industrial Lighting Practice — Art O'Conner and William Kuhnke
December 11 — Outdoor Lighting Applications — B. R. Bunn and M. H. Bruesewitz

Showing their versatility, I.E.S. members and employes of Wisconsin Electric for the final meeting prepared and served an excellent steak dinner.

REGISTRATION was 78 for the Milwaukee Section's course on Commercial and Industrial Lighting Fundamentals. Classes were held weekly from October 22 through December 11.

ABOUT PEOPLE

Curtis Lighting of Canada Ltd. announces the appointment of **Hedley F. Davidson** as chief engineer. Mr. Davidson's work will include engineering on special lighting applications and product development. Prior to this appointment Mr. Davidson had been employed at the Research Division of Ontario Hydro, Toronto, as Supervising Engineer of the Illumination Section.

Charles J. Meloun has been appointed manager of engineering for the General Electric Outdoor Lighting Dept., Hendersonville, N. C. Mr. Meloun was previously manager of industrial machinery engineering in the G-E Equipment Industries Engineering Section, Schenectndy, N. Y. In his new assignment he succeeds **H. J. Flaherty,** who has been named a consultant.

Electrical Testing Laboratories, Inc., New York, N. Y. announces the election of **Hoffman Stone Beagle** as President. Mr. Beagle joined ETL in 1953 as Assistant to the President and became Executive Vice-President in 1956. Mr. Beagle succeeds **W. F. Little,** who retired last December 31, after nearly fifty years with the company.

Dr. Clarence Zener has been appointed director of the Westinghouse Research Laboratories, assuming the position after five years as associate director and a year as acting director. The Laboratories have only recently occupied completely the new research facilities in Churchill Borough, ten miles east of downtown Pittsburgh.

March A. deFerranti, who for two years has headed General Electric's "university for managers" at Crotonville, N. Y., has been appointed general manager of the company's Distribution Transformer Department, Pittsfield, Mass. He succeeds **Raymond W. Smith,** who became general manager of the Transformer Division on January 1.

Westinghouse Electric Corp., Lamp Division, Bloomfield, N. J., has appointed three managers in the photo lamp department. **Willett R. Wilson** has been named commercial engineering manager; Frederick H. Rixton, engineering manager, and **Earl J. Aberle,** manufacturing manager.

The Westinghouse Lamp Division has also announced the appointment of engi-

(Continued on page 16A)

(*Continued from page 15A*)

neering managers in three other departments. In the miniature lamp department, **Philip F. Dietz** has been named to the position; **Wilbert A. Taebel** has been appointed engineering manager of lamp parts department; and **O Bruce Goldsmith** is the new manager of engineering in the large lamp department.

By unanimous action of Council at its last meeting, **Carlyle A. Atherton** was elected Member Emeritus of the I.E.S. Mr. Atherton retired last year from Westinghouse International Co., New York, following a distinguished career in lighting in this country, and in Geneva, Switzerland. Active for some 34 years in I.E.S., he was also, on election in 1949, the first American Secretary of the C.I.E.

Purchase of the stock of the Holdenline Co., Cleveland, Ohio, has been announced by **John C. Virden, Jr.**, president of the John C. Virden Co. **Harry Schockett** of Virden will be responsible for design and engineering in the new subsidiary and **Anthony Milicia** has become plant superintendent.

TWO meetings of the New England Section, I.E.S. November meeting (above) was on Trends in School Lighting, guest speaker Willard Allphin. Left to right in photo are: front row, Walter Ball, Willard Allphin, Carleton Holden, Ralph Huse; rear row, Eugene Frost, Donald Adamson, Leonard Bean and Raymond Smart. December meeting (photo below) featured Dean Farnsworth speaking on The Color Environment in Lighting Installations. Left to right are: Carleton Richmond, Jr., Walter Murphy, Carleton Holden, Mrs. Dean Farnsworth, John E. Carr, Commander Farnsworth and Leonard Bean.

Mark C. Pope Associates, Atlanta sales representatives for C & D Batteries, have added **Eugene L. Krauss** to the staff. Mr. Krauss comes to C & D following eight years' service with the Storage Battery Division of Thomas A. Edison Inc., where he was a district manager.

Thomas Industries Inc. has acquired the plant of the Radiant Glass Co., producers of hand-blown glass, at Fort Smith, Arkansas, which will be operated as the Radiant Glass Division of Thomas Industries Inc. **George D. Carney**, president and principal stockholder, will no longer remain active in the affairs of the company.

Philadelphia Electrical & Manufacturing Co. announces the appointment of **E. Fred Bahls** as Sales Manager. Mr. Bahls has been associated with the company for over twenty-three years.

The Miller Co., Meriden, Conn., has named **Dean J. Harryman** as sales representative for the Illuminating Division in the Milwaukee territory. Prior to his association with Miller, Mr. Harryman was with the General Electric Supply Co.

Robert G. French, sales manager for the Steber Manufacturing Co., has formed a new sales agency for the Chicago area. The agency, operating as Midwestern Electrical Representatives, has offices at 4754 West Washington Blvd., Chicago. Associated with Mr. French will be **George French** and **B. H. Etsinger.**

P. B. Clark, Line Material Co. Division of McGraw Electric Co., has been named chairman of the Technical Committee on Street Lighting for the National Electrical Manufacturers Association.

Unistrut Products Co., Chicago, announces the appointment of three managers of newly created divisions: **George McKay**, manager, electrical and mechanical construction division; **C. T. Walas**, manager, materials handling division; **F. W. Ingraham**, manager, partitions and display division. **A. E. Serewicz** has been named sales supervisor of Unistrut activities in Canada.

Robert C. Evans has been named sales representative in the Utah-Idaho area by the Illuminating Division of the Miller Co. Mr. Evans is sales manager of the Ariel Davis Supply Co., Inc., agents for the Ariel Davis Manufacturing Co. in the Intermountain states.

(*Continued on page 18A*)

Now... a luminaire that operates in freezing temperatures!

The new Westinghouse LT operates in low or variable temperatures — making it ideal for lighting cold storage warehouses, food lockers, shipping platforms and marquees.

Designed in cooperation with the Refrigeration Institute, the Westinghouse LT luminaire gives low heat output and high light output. A clear, ribbed plastic enclosure protects the lamp from air currents to insure maximum efficiency of the F72T-12, 100-watt, rapid-start lamps. In addition, the LT's porcelain finish resists corrosion in moist atmospheres and enhances its appearance. Why gamble with fixtures that were designed for other purposes.

Doesn't the LT suggest an application to you?

For real lighting quality, specify the Westinghouse LT luminaire.

See your Westinghouse distributor or write, Westinghouse Electric Corp., Lighting Division, Edgewater Park, Cleveland, Ohio.

Look for other new Westinghouse lighting products . . . soon to be announced!

J-04399-B X

YOU CAN BE SURE... IF IT'S Westinghouse

(Continued from page 16A)

IT SEEMS TO ME

Characteristics of Polystyrene

We would like to correct an error we made in our chart, Table I — Properties of Plastics Used in Light Control, in the paper, "Plastics in Lighting," November 1956 I. E. Weatherability ratings for General Purpose Polystyrene and Light Stabilized Polystyrene should be corrected to:

	General Purpose & Heat Resistant	Light Stabilized
Weatherability	Poor-Fair	Fair to Good

W. E. BROWN, *Plastics Technical Service, The Dow Chemical Co., Midland, Mich.*

1957 Regional Conferences, I.E.S.

Region	Place	Date
Pacific Northwest	Empress Hotel Victoria, British Columbia	March 28-29
South Pacific Coast	Statler Hotel Los Angeles, California	April 3-5
Inter-Mountain	Alvarado Hotel Albuquerque, New Mexico	April 11-12
Southwestern	Holiday Inn Oklahoma City, Oklahoma	April 28-30
Midwestern	Pfister Hotel Milwaukee, Wisconsin	May 9-10
Great Lakes	Pantlind Hotel Grand Rapids, Michigan	May 13-14
Canadian	Sheraton Brock Hotel Niagara Falls, Ontario	May 16-17
East Central	William Penn Hotel Pittsburgh, Pennsylvania	May 23-24
Northeastern	Statler Hotel New York, New York	June 13-14

BOOKS AND PAMPHLETS

1955 Supplement to the Bibliography and Abstracts on Electrical Contacts, Special Technical Publication No. 56-J. Available from the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. 48 pages, 6 x 9, heavy paper cover, $1.00.

This bibliography, including an introduction, an author index, a subject index and series of references, is an annual supplement to the 1952 Bibliography. Previous supplements were published in 1943 and 1954.

Quality Control for Plastics Engineers, published by Reinhold Publishing Corp., New York, N. Y. Available from the Society of Plastics Engineers, 34 East Putnam Ave., Greenwich, Conn. 160 pages. $3.96 to S.P.E. members, $4.95 to others.

Produced by the Society of Plastics Engineers Committee for Quality Control under the chairmanship of Dr. Lawrence M. Debing, Monsanto Chemical Co., this is the first in a series of technical volumes to be published by S.P.E. It introduces the subject of statistical quality control to plastics engineers, referring specifically to examples of applications currently used in the plastics industry.

Your Guide to NEMA Standards Publications, available from the National Electrical Manufacturers Association, 155 East 44th St., New York 17, N. Y. 17 pages, no charge.

More than 150 standards publications developed by subdivisions of N.E.M.A. are described in this booklet. These cover eight electrical classifications: appliances, illuminating equipment, signalling and communication equipment, industrial apparatus, building equipment and supplies, insulating materials, insulated wire and cable, and generation, transmission and distribution equipment.

This Is Glass, available from Corning Glass Works, Corning, N. Y., 64 pages, no charge.

Manufacturing methods, applications and the history of glass are explained in this booklet, illustrated with charts, drawings and 130 photographs. The booklet covers such topics as what glass is, how it is made, and how it is used.

(Continued on page 42A)

Want Something Put in the Progress Report?

The Committee on Progress, James H. McCulloch, Chairman, asks that snapshots or commercial glossies of new equipment or new applications be submitted for consideration by the Committee at their April meeting, looking ahead to the 1957 Progress Report.

To quote Mr. McCulloch: "The preparation of a report for publication in I.E. is actually the Committees' major assignment, but 'The Progress Report' to many people means the popularized presentation at the National Conference. To keep these presentations interesting, material submitted is measured against these criteria: (1) Has it ever been shown on a Progress Report? (2) Does it lend itself to an interesting presentation to a general audience — or a general reader? (3) Can it be hauled along on the 'road shows,' or can a slide be submitted for the equipment? (4) Will an audience stay long enough to see it? (or reader read it?)

"No attempt is made to separate 'good' from 'bad.' Technicalities are left to the technical papers; styles left to the trade journals; and choice between near-duplicates from two manufacturers is often made by 'which one will show better.' Colored slides have been used for several years with increased audience appeal. Expenses of pictures, slides and shipment are borne by the manufacturers. Glossies cannot be returned; equipment will be returned immediately after the Atlanta Conference; and slides will be returned during the summer of 1958.

"Get your item in early!"

Glossies should be sent to the Committee Chairman, James H. McCulloch, c/o Independent Testing Laboratories, 1928 14th St., Boulder, Colorado. Attach a short description of the newsworthy points to the glossies, with your name and address.

CHECK THESE "SPECS"

Constructed of more die-formed parts than almost any other fixture of its type for rugged performance.

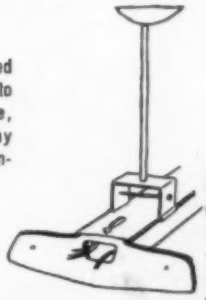
For general lighting the SIXTEEN-EIGHTY is unsurpassed for efficient long-term lighting economy.

Double acting positive spring clips retain side panels firmly to prevent rattling and to allow simple snap-in replacement.

An advanced concept of lighting comfort . . . the Sunbeam SIXTEEN-EIGHTY series has been critically engineered for the ultimate in universal application and lighting comfort.

Extruded metal rail reinforced plastic side panel to insure freedom from warpage or accidental breakage while enhancing design appearance.

Heavy gauge, die-formed end plates rigidly held to main channel. Large, smooth-edged wireway opening permits fast continuous row mounting.

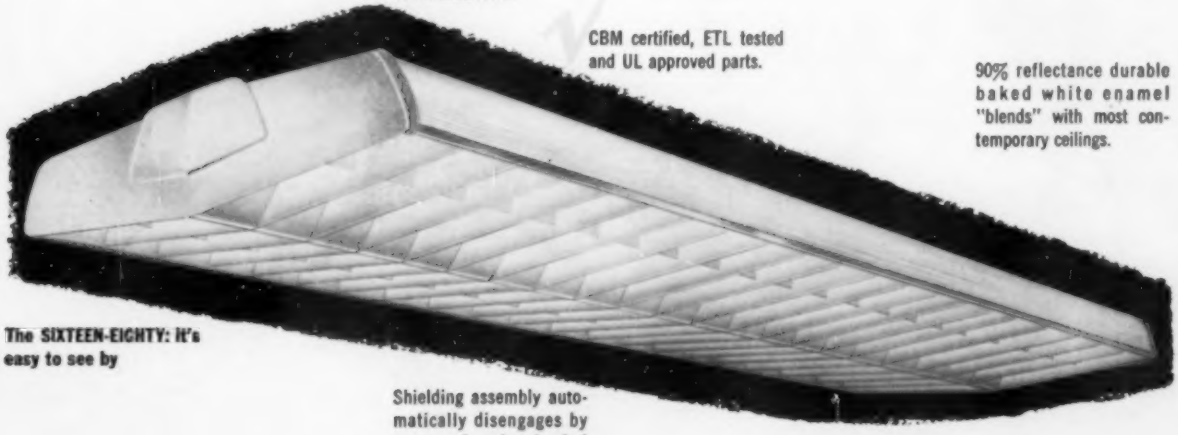


For increased flexibility and ease of installation, die-formed channel accommodates sliding clamp hangers. No connectors required for continuous rows.

Translucent white plastic side panels of light stable Dow virgin #647 Styron are ribbed and contoured for architectural appeal. A 10° slant helps maintain longer lasting high efficiency and contributes to better brightness control from normal viewing angles.

CBM certified, ETL tested and UL approved parts.

90% reflectance durable baked white enamel "blends" with most contemporary ceilings.



The SIXTEEN-EIGHTY: it's easy to see by

Shielding assembly automatically disengages by means of spring-loaded latches and remains suspended from channel by jack chain for quick accessibility.

Surface or pendant mounted by use of nearly universal knockouts and sliding clamp channel.

Exacting photometric control achieves extremely high efficiency (up to 87%) with a controlled distribution of approximately 60% up and 40% down, a brightness of less than 1 c/in² within the shielded zone.

Rigidly constructed, vibration-free interlocked louver provides high, comfortable shielding of 35° x 35°—better than most school requirements.

Engineered for maximum heat dissipation for longer ballast life.

Bonderized for long-lasting corrosion resistance and tough paint adherence.

SUNBEAM LIGHTING COMPANY

777 East 14th Place, Los Angeles 21, California

For technical information on this advanced concept of lighting, write for bulletin F-2.

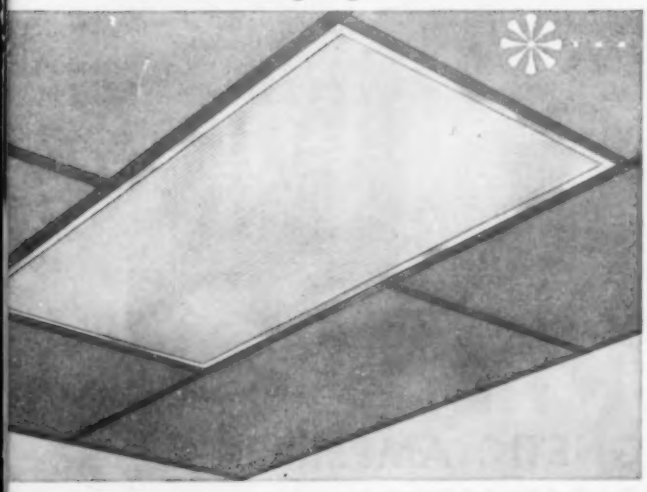
* Arthur W. Siegel, Massachusetts Representative, one of Smithcraft's nationwide sales organization

Smithcraft Troffers and other fine lighting units are installed in thousands of offices, factories, stores, schools and diversified interiors from coast to coast. Wherever good lighting is important, you'll find . . .

SMITHCRAFT—"AMERICA'S FINEST FLUORESCENT LIGHTING".

. . . . . the man from *Smithcraft*

When you put his knowledge of lighting to work for you, your ideas turn into reality! His experience enables him to translate architectural concepts into effective lighting results. You can have confidence in his judgement because he knows how to adapt the flexibility of Smithcraft's line of lighting units into time-saving, economical solutions to lighting problems. Call him in to consult with you or your lighting engineers on any job on your boards . . . you'll find he knows blueprints and budgets as well as he knows lighting!



. . . the 24" wide troffer from *Smithcraft*

Extremely versatile, architecturally integrated recessed lighting, Smithcraft two-foot wide troffers permit wide freedom in the creation of interesting and functional lighting patterns. They present a modern, trim, clean appearance free from light leaks or blemishes and with no visible catches, hinges, or screws. In glass or plastic-shielded units, a clean expanse of shielding is uninterrupted by cross-braces. Doors open or close with simple upwards pressure (patented) and simply lift off for maintenance. In louvered units, louvers are held by Smithcraft's patented Duo-Cam hangers. Louvers hinge from either side and are removed without tools or loose parts.

Smithcraft two-foot wide troffers are adaptable to today's most common ceilings. They are fast, easy and economical to install. There is a wide variety of shielding media available including Steel louvers (providing 30° x 30° shielding), Plastic louvers (42° x 42° shielding), Albalite glass, Corning Pattern #70 glass, Ribbed glass, Polycraft Plastic Dish and Acrylic Plastic.

Smithcraft, a leader in the progressive design and development of fluorescent lighting fixtures manufactures a complete line of units specifically designed to meet a wide variety of lighting applications. The Smithcraft catalog contains pertinent and useful information on this line of fixtures and is a valuable aid in the design of lighting layouts or in ceiling planning. Make sure your copy is in your file. If it isn't, let us send you one.

Smithcraft 2'-wide Metro Troffers provide 75 footcandles of extremely even illumination throughout Beerman's Department Store, Dayton, Ohio. Metro Troffers are lay-in troffers for inverted "T" Grid ceiling systems.

Smithcraft
LIGHTING
CHELSEA 50, MASSACHUSETTS

PLEASE ATTACH TO YOUR BUSINESS LETTERHEAD and mail to
Smithcraft LIGHTING, CHELSEA 50, MASS. IE-2

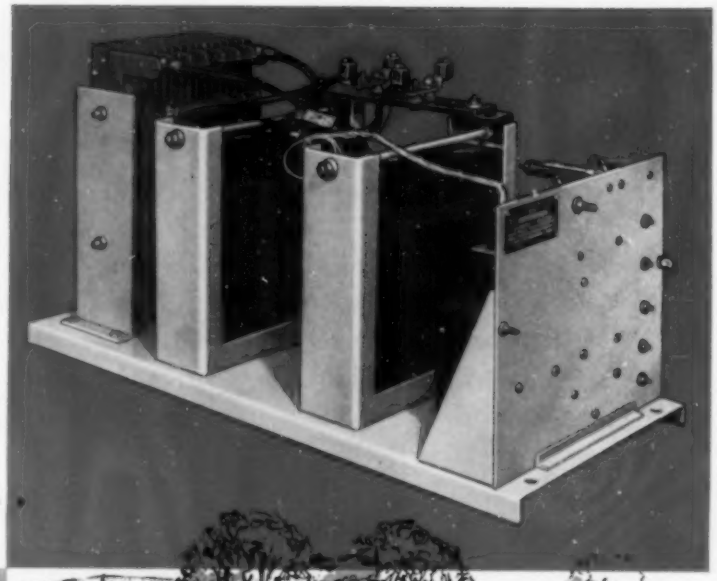
NAME _____ TITLE _____

☐ Please send me the monthly publication, "Light Side of the News", so that I can keep in touch with the latest trends in lighting.

☐ Please send me "YOUR CEILING PLANNING COMES TO LIFE", a complete handbook on one and two-foot wide SMITHCRAFT ARCHITECTURAL TROFFERS.

☐ Please send me the complete SMITHCRAFT CATALOG, containing data on "America's Finest Fluorescent Equipment".

Modern Lighting Control *for the modern theatre....*



PURDUE MEMORIAL UNION—HALL OF MUSIC ANNEX
Lafayette, Ind.
Architects: Walter Scholer and Associates
Genl. Contractor: K. H. Kettelhut
Elec. Contractor: Hatfield Electric Company
Switchboard Manufacturer: Metropolitan Electric Manufacturing Company

Typical console manufactured by Lumi-Tron Division of Metropolitan Electric Manufacturing Co.

VICKERS* MAGNETIC AMPLIFIER TYPE DIMMERS!

Maximum flexibility...rapid between-scene changes... accurate control of lighting intensities. These are important requisites of lighting control switchboards for the modern stage.

In Purdue University's magnificent new $9,000,000 Memorial Union—Hall of Music Annex (above), 80 Vickers Magnetic Amplifier Type Dimmers have been incorporated in the lighting systems for the Loeb Playhouse and the Experimental Theatre.

These dependable dimmers meet today's exacting lighting control needs with: fast response, smooth transition through the entire lighting range, new 30-1 load range, inherent stability, reduced weight and size through redesigned closed-core power section, elimination of tubes and moving parts, and other superior features.

Write today for 12-page bulletin on lighting control.

DESIGN ENGINEERS: Write for information concerning opportunities in our expanding program.

*TRADEMARK

VICKERS ELECTRIC DIVISION

VICKERS INCORPORATED a unit of Sperry Rand Corporation

1863 LOCUST STREET • SAINT LOUIS 3, MISSOURI

now **METALCRAFT**

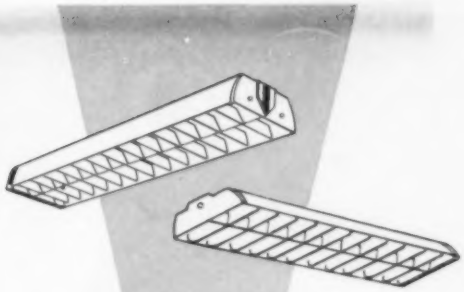
CROSS-BREEDS

2 famous luminaires

to produce the

NEW, IMPROVED

Astra LITE

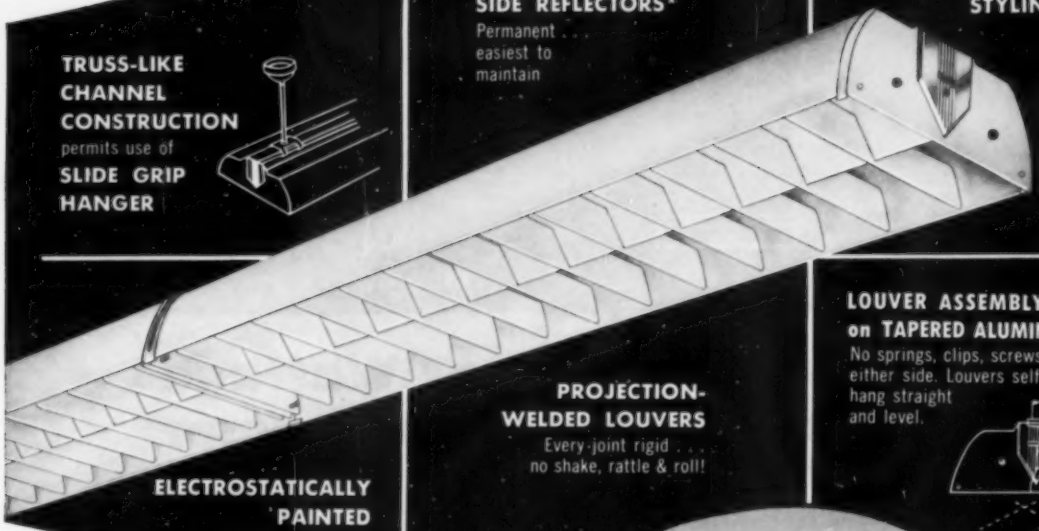


Combining the finest features of the original ASTRA-LITE and the GILL "300" LINE!

SHALLOWER, TRIMMER STYLING!

CURVED GLASS SIDE REFLECTORS*
Permanent . . . easiest to maintain

TRUSS-LIKE CHANNEL CONSTRUCTION
permits use of **SLIDE GRIP HANGER**



LOUVER ASSEMBLY HINGED on TAPERED ALUMINUM PINS
No springs, clips, screws. Lower either side. Louvers self-aligning, hang straight and level.

PROJECTION-WELDED LOUVERS
Every joint rigid . . . no shake, rattle & roll!

ELECTROSTATICALLY PAINTED
Quality controlled finish.

metco Lighting

PRACTICAL . . ECONOMICAL . . SUPERIOR!

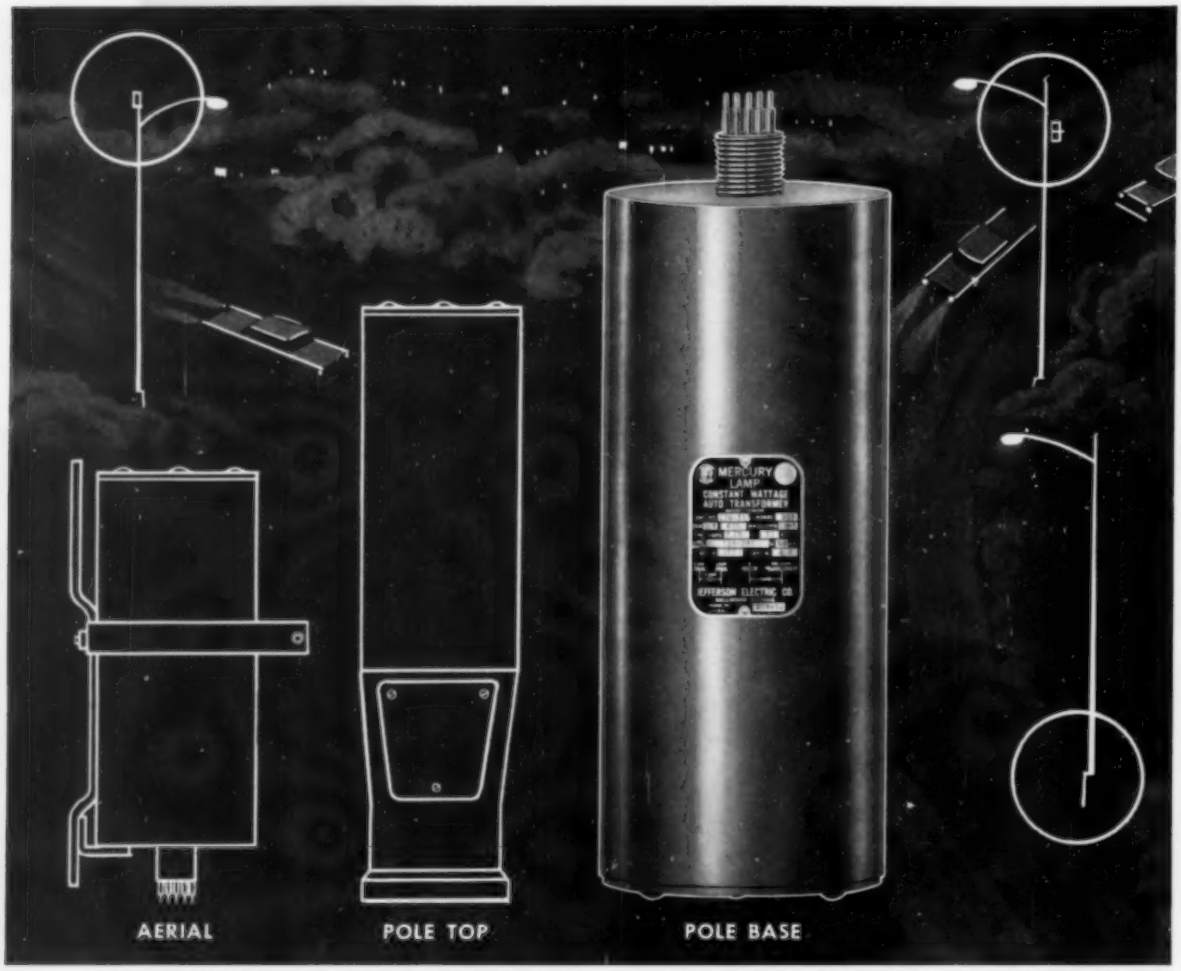
ASTRA-LITE is available in two and four lamp slimline or rapid start, 4', 6' and 8' lengths, for pendant or surface mounting. General diffuse classification, direct or semi-direct. Overall efficiency approximately 84%. Brightnesses meet school and office lighting recommendations. Fleur-O-Lier approved.

***Also available with new extruded plastic or metal side shielding.**

Certified FLEUR-O-LIER CERTIFIED

Sold only through qualified electrical distributors

METALCRAFT PRODUCTS COMPANY, INC., Mascher and Lippincott Streets, Philadelphia 33, Pa.



New! Jefferson Constant Wattage Mercury Lamp Transformer

New Electrically—New Mechanically

☆ **Stocking Requirements Cut in Half.** A new, slimmer shape and new mounting accessories make it possible to use this *one* transformer for aerial, pole top, or pole base applications.

☆ **Easier Handling in Warehouse and on the Job.** A one-inch reduction in diameter further simplifies the stocking problem and combines with the new threaded pipe nipple for *easy*, *fast* installation.

☆ **Improved Lumen Maintenance.** Engineered to produce a better starting current wave shape for smooth, quiet starts; plus an operating lamp current crest factor which meets *all* lamp manufacturers' requirements.

☆ **Dependable Operation.** Designed and tested to provide:

1. Constant lamp wattage of ±2% over line voltage range of ±13%.
2. *Automatic* compensation for line voltage variations and line drops.
3. Positive cold weather starting down to —30°F.

☆ **Maximum Versatility.** Designed for use with AH-1, EH-1, JH-1, and *all* similar 400 watt lamps. *These transformers are compensated to provide full rated light output in any lamp burning position consistent with lamp manufacturers specifications.*

For full details and experienced engineering recommendations, contact your Jefferson Representative or write JEFFERSON ELECTRIC COMPANY, Bellwood, Illinois, today.

Jefferson Electric Company

BELLWOOD, ILLINOIS

The thinnest fixture ever designed with no dark areas

the new Gibson Ceilo • 35

This beautiful surface-mount fixture is only 2¾" deep, the thinnest ever designed without panels or strips to conceal the ballasts. In the Ceilo-35, the ballasts are mounted in the sides, an exclusive Gibson development which provides a smooth, unbroken panel of light.

Not only is this new fixture the best-looking you ever saw, it has many new and practical design features to make installation faster and maintenance easier.

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Makers of the world's most versatile fixtures

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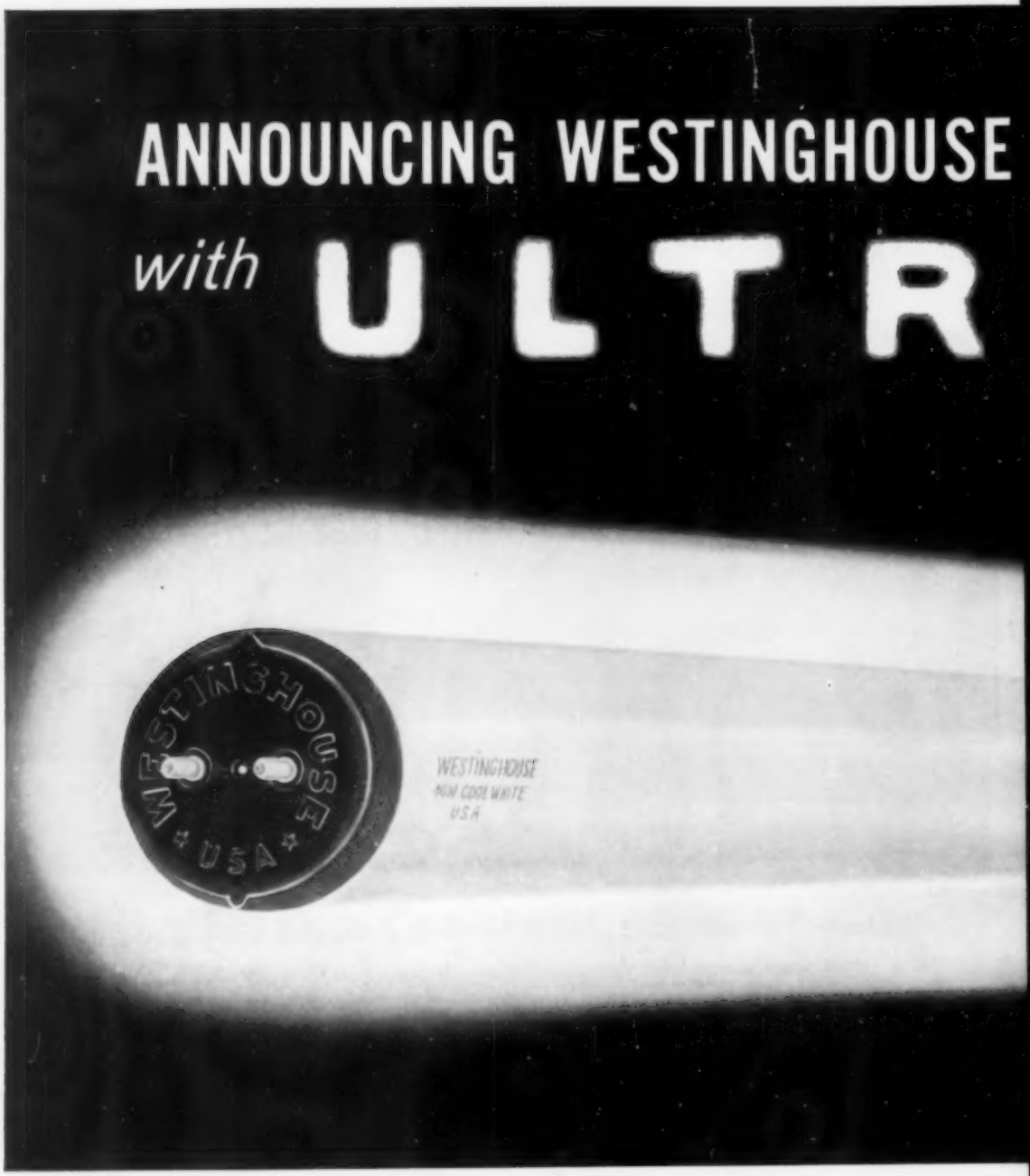
Gibson LIGHTING

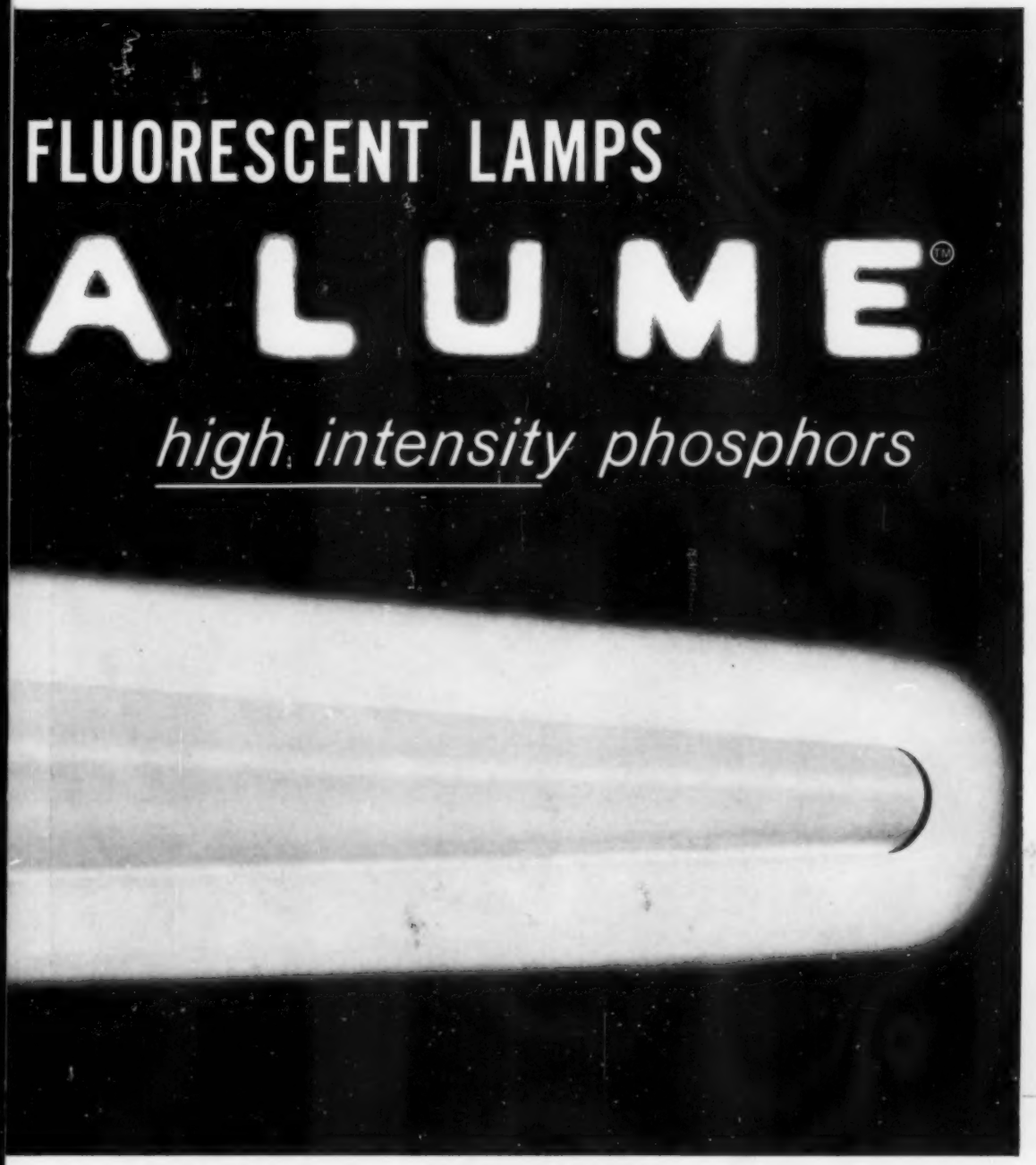
GIBSON Manufacturing Co.

1919 Piedmont Circle, N.E., Atlanta 9, Georgia

ANNOUNCING WESTINGHOUSE *with* ULTR



YOU CAN BE SURE... IF IT'S Westinghouse



START BRIGHTER . . . MAINTAIN BRIGHTNESS LONGER . . .

- **MORE LUMENS PER WATT**—more light for your dollar.
- **PLUS UNIFORM END-TO-END LIGHT** . . . always perfectly color-matched . . . maximum light output maintained throughout life—and carrying the **WESTINGHOUSE ASSURANCE** of performance satisfaction or full purchase price refund.
- Get the most for your lighting dollar—call your Westinghouse Lamp Distributor today, or write Westinghouse Lamp Division, Dept. IE, Bloomfield, N. J.

SEATTLE ART MUSEUM/ARCHITECTS • YOUNG, RICHARDSON, CARLETON AND DETLIE, SEATTLE/DESIGNER • HARRY C. LYNDE CO., SEATTLE

HONEYLITE®

LIGHT-DIFFUSING ALUMINUM HONEYCOMB

A development of HEXCEL PRODUCTS INC.

951 SIXTY-FIRST STREET, OAKLAND 8, CALIFORNIA

THE FINE ART OF LIGHTING

Whether you're lighting priceless objects, not-for-sale . . .
or merchandise priced for quick sale, Honeylite's gentle but completely shadow-free light makes "seeing" a pleasure.
But Honeylite doesn't stop at being just one of the very best light diffusing elements. Salespeople, and more important, customers will tell you that Honeylite's full air circulation makes a room as refreshingly airy as a summer morning . . .
cool to work in, and fun to shop in.
And Honeylite's gossamer-weight, all-aluminum construction reduces the costly man-hours of installation, and lengthens the life of lighting units.
For price lists and detailed information call your dealer or write to Hexcel Products Inc., 951-61st Street, Oakland 8, Calif.

Every level of light . . . from dark to full bright . . . with LUXTROL

"...most talked-about feature!" "...fascinates home-buyers!" "...helps sell new homes!" —that's what builders are saying about the profitable new LUXTROL Light Control

From all parts of the country, builders write that LUXTROL is making a big hit with home-buyers . . .

Hillcrest Lumber Company, De Pere, Wisconsin "...LUXTROL is the most talked-about feature of the Better Homes & Gardens Idea Home. ...people never thought it possible that light could create such decorative effects!"

Rolling Ridge Homes, Northport Village, Long Island ". . . prospective buyers are most fascinated by LUXTROL. They love the idea of dialing any degree of light they want—from a dim glow to complete brightness! . . . really helping to merchandise houses!"

Ernest Widmer, Builder, Daytona Beach, Florida "LUXTROL Light Controls help sell homes because they're trouble-free, economical to purchase and operate, and they provide easy selection of light levels for any occasion . . ."

H. C. Roberts & Sons, Anaheim, California "Our Electri-Living Home includes all the latest products... the unequalled flexibility of light provided by LUXTROL is definitely outstanding. It gives the homeowners light for every mood and every seeing need."

Sell LUXTROL as an exciting extra to the profitable new-home market

LUXTROL shows off your customers' new homes in their *best light*. It adds that final, ultra-modern touch that home-buyers really go for!

You can recommend LUXTROL for any type of building. For fluorescent, incandescent, or cold-cathode lighting. Easy to install — simply replaces ordinary wall switches. Safe — a precision-built, cool operating auto-transformer, not a rheostat.

The moderate cost of LUXTROL makes it a natural for homes in *every* price range. Mail the coupon *today*.

new LUXTROL light control

A product of THE SUPERIOR ELECTRIC COMPANY

THE SUPERIOR ELECTRIC COMPANY
5027 Demers Avenue, Bristol, Connecticut
Send me literature and where to get delivery of new LUXTROL *Light Control.*

Name_____
Company_____
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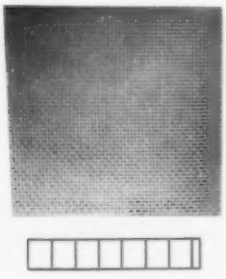
City_____ Zone____ State____

You'll put your client in the best

These represent just a few of the many Corning glasses specially designed for engineered lighting applications.

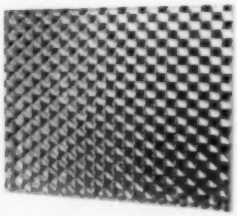
For high efficiency, uniform, general lighting with incandescent lamps, Corning PYREX Concave Lenslites are recommended. Made of a PYREX brand glass, they provide freedom from breakage even in outdoor service with high wattage bulbs. Designed on the Fresnel principle, they give exceptionally even light distribution over a wide area.



Corning Fota-Lite combines the easy-to-clean, easy-to-handle advantage of a smooth, static-free sheet of glass with the control that louvers afford. The effect is of crystal-clear cells separated by white opal louvers. Available with vertical louver pattern for 45° cutoff, and with 30° slanted louvers for offset beam lighting.

SEE OUR CATALOG
IN SWEET'S ARCHITECTURAL FILE
OR WRITE FOR COPY

possible light with Engineered Lighting



For uniform, efficient light distribution with low surface brightness, specify Corning Pattern No. 70 Low-Brightness Lens Panels. Optically correct 6-sided pyramids distribute the light in all directions.

For diffused light in the working area with reduced brightness contrast between ceiling and fixture, specify Corning Curved Alba-Lite Panels. Made of a light opal glass the curved panels afford complete diffusion, excellent brightness control free of color distortion, with a part of the light delivered above the horizontal for reduction of contrast in the ceiling area adjacent to the fixture.

Your client's offices, his people, his goods . . . all are in their best possible light . . . when you utilize the principles of engineered lighting in designing his lighting installations.

Engineered lighting is *on-the-job* lighting. It means light that is adapted, through Corning's optically engineered glassware, to the illumination needs of a specific job. It is the key to better working efficiency, comfortable seeing, increased sales. It does the job with light that glass can do best.

As the transmitting and control medium, glass determines the intensity of the light, its direction, its color-revealing fidelity, its comfort. As a part of the lighting fixture, glass also determines the fixture's attractiveness, its ability to fit into the decorative scheme . . . and its ease of maintenance and cleaning.

Corning's laboratories are continually at work to develop more applications for lighting glassware, new glasses, and new methods of controlling light with glass. The experience gained here is available to you at any time—at any stage of an installation—through Corning's staff of lighting consultants.

Send, now, for your copy of Corning's new "Application Guide for Commercial Lighting Glassware." It will help you in selecting the lighting glassware that meets your specific application requirements for offices, schools, banks, public buildings, stores, displays, hospitals. Write, wire, or phone Lighting Sales Department, Corning Glass Works, Corning, New York.

CORNING GLASS WORKS
Lighting Sales Dept.
61-2 Crystal St., Corning, N. Y.

Please send me a copy of your new "Application Guide"

Name.....

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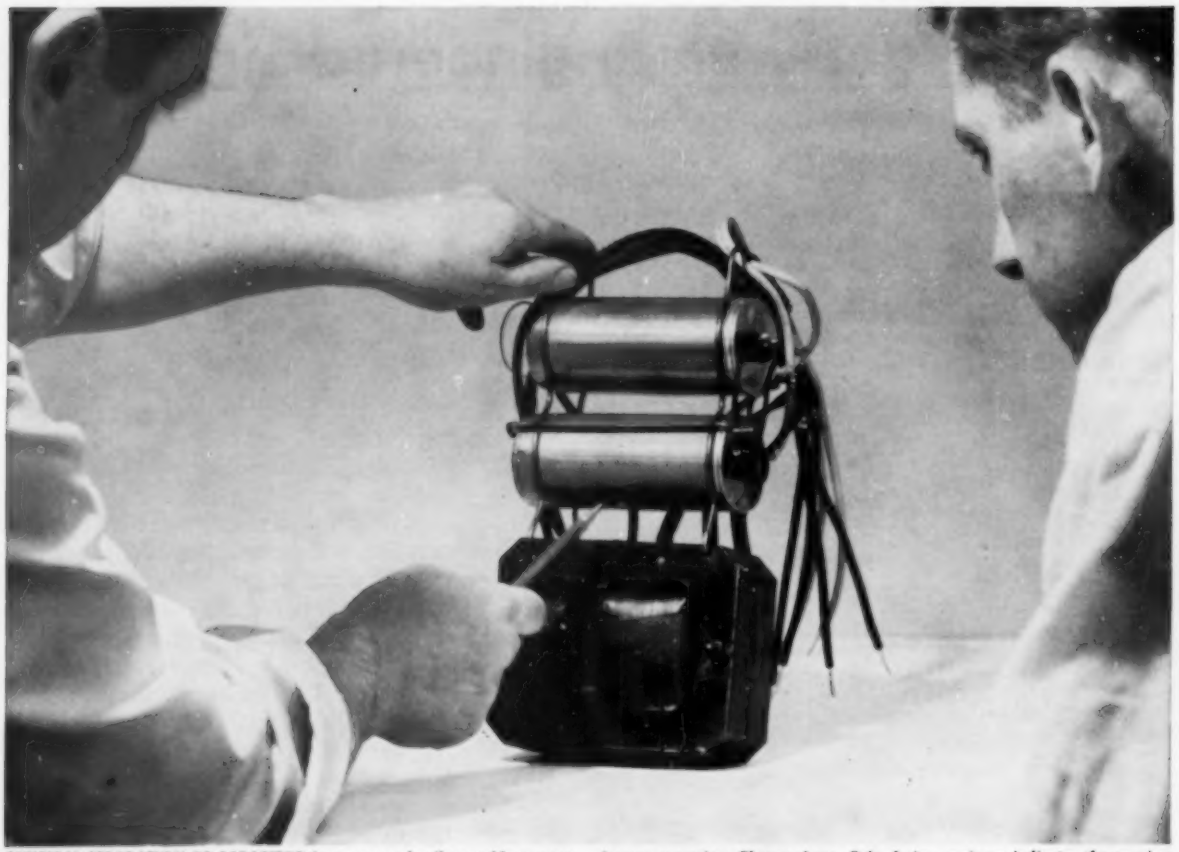
CORNING GLASS WORKS, CORNING, N. Y.
61-2 Crystal Street

Corning means research in Glass



PHYSICAL SEPARATION OF CAPACITOR *from core-and-coil assembly assures protection against capacitor failure due to heat arising from normal transformer operation. Shown above, Sola design engineer indicates the spacing of capacitors (top) from core-and-coil assembly in the Sola transformer.*

Design Feature Protects Capacitor Life in Sola Mercury Vapor Lamp Transformers

Capacitor failure is a major cause of malfunction of outdoor mercury vapor lamp transformers. Almost invariably, heat normally generated by transformer operation is responsible. Sola Constant Wattage Mercury Vapor Lamp Transformers are designed to protect against capacitor failures by providing safe physical separation of capacitor from the core-and-coil assembly.

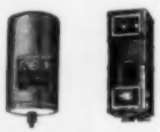
This design feature is indicative of the mechanical and electrical design caliber of Sola Constant Wattage Mercury Vapor Lamp Transformers. The result is superior performance, reliability, and reduced system maintenance cost for outdoor mercury vapor lighting.

Sola Constant Wattage Transformers offer unique electrical characteristics:

- Lamps remain lit even when line voltage dips as low as 75v on a 115v line.
- Energy to lamps is regulated within $\pm 2\%$ in spite of line voltage swings as great as $\pm 13\%$.
- Regulated voltage, current, and wattage permit continuous stable operation — extend lamp life.

When you're next concerned with design, specification or installation of outdoor mercury vapor lighting — shopping centers, parking lots, service stations, playfields, plant area protection — investigate the advantages of Sola Constant Wattage Mercury Vapor Lamp Transformers. Your Sola representative, listed below, will be happy to provide prompt attention to your inquiries.

SOLA *Mercury Vapor Lamp* **TRANSFORMERS**



Write for Bulletin 23B-MV-219
SOLA ELECTRIC CO.
4633 W. 16th Street
Chicago 50, Illinois

CONSTANT VOLTAGE TRANSFORMERS for Regulation of Electronic and Electrical Equipment • **LIGHTING TRANSFORMERS** for All Types of Fluorescent and Mercury Vapor Lamps. • **SOLA ELECTRIC CO.**, 4633 West 16th Street, Chicago 50, Illinois, Bishop 2-1414 • *NEW YORK 35:* 103 E. 125th St., TRafalgar 6-6464 • *PHILADELPHIA:* Commercial Trust Bldg., Rittenhouse 6-4988 • *BOSTON:* 272 Centre Street, Newton 58, Mass., Bigelow 4-3354 • *CLEVELAND 15:* 1836 Euclid Ave., PRospect 1-6400 • *KANSAS CITY 2, MO.:* 406 W. 34th St., Jefferson 4382 • *LOS ANGELES 23:* 3138 E. Olympic Blvd., ANgelus 9-9431 • *TORONTO 17, ONTARIO:* 102 Laird Drive, Mayfair 4554 • *Representatives in Other Principal Cities*

Diffusers of Du Pont LUCITE used in the American Hardware Mutual Insurance Company's new home office, Minneapolis, Minn. Architects: Thorshov & Cerny, Minneapolis. Lighting fixtures by Curtis Lighting, Inc., Chicago, Ill. LUCITE extruded by Sandee Manufacturing Co., Chicago.

Better looking, better lighting

with diffusers of Du Pont LUCITE®

The lighting system shown above is typical of the entire installation at the American Hardware Mutual Insurance Company's new home office which uses diffusers of Du Pont LUCITE acrylic resin. The objective . . . to design a low-brightness, glare-free illumination to be the basis of an integrated ceiling system including lighting, sound-absorption elements and ventilating facilities.

Luminaires were required that would reduce the brightness ratios between luminous and non-luminous elements and combine maximum comfort with maximum efficiency. After studying several different systems, architects Thorshov & Cerny selected luminaries having diffusers of Du Pont LUCITE.

Luminaires of LUCITE acrylic resin transmit optimum light without specular glare or shadow. They are strong, durable, dimensionally stable and free from discoloration. Light in weight and easy to handle, diffusers of LUCITE are easy to install . . . maintain their clarity and beauty.

SEND FOR FREE BOOKLET. Twelve-page illustrated booklet describes all the latest property and application data on LUCITE acrylic resin for lighting. For your free copy, write E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department, Room 432, Du Pont Building, Wilmington 98, Delaware.

DU PONT

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

We're busy planning big things for *YOU* in *ATLANTA!*

The National Technical Conference Executive Committee* at work in a planning session for the 1957 Conference of the Illuminating Engineering Society in Atlanta, Georgia.

**Left to right: Rita Knoell, Ladies; Judd Lough, Finance; Emily Alexander, Ladies; Al E. Bruner, Sports; J. E. Sweatte, Hotel; Mary Bush, Ladies; W. M. Pearson, Chairman, Georgia Section; Joe B. Browder, Chairman, 1957 Conference Executive Committee; Jim Forbes, Chairman, I.E.S. National Technical Conference Committee; Dex Hinckley, Executive Secretary, I.E.S.; Jack Murrah, Publicity; Jack Burns, Entertainment; John Brun, Manager Georgia Section; Cecil Canon, Reception.*

ATLANTA is a showcase and nerve center of the New South—it's a city full of push and purpose, of such booming business that it's spreading a pattern of progress throughout Georgia and the Southeast, but . . .

ATLANTA is, at the same time, a city of gracious living, of beautiful homes, and year-round gardens, with plenty of the traditional Southern hospitality.

The **GEORGIA SECTION** was the pioneer I.E.S. organization in the Southland and has carried on the Society's activities aggressively for the past 17 years. Its members plan to serve as hosts to the 1957 Technical Conference in a fashion that will surpass even the memorable 1941 convention in Atlanta.

Y'ALL COME!

1957 National Technical Conference

Illuminating Engineering Society

Headquarters:

Atlanta Biltmore Hotel

"The South's Supreme Hotel"

Dates:

September 9 thru 13, 1957

Perfeclite now offers a new **hammer lock** design in incandescent ceiling pan lighting fixtures. No other ceiling pan fixture on the market today has all these engineering features:

- Globe opens on **hinge** for quick easy cleaning and relamping.
- Unique **safety locking fitter** holds globe in place without bothersome screws, unsightly extensions or trick springs. Globe is secured with lugs by simple twist of the wrist.
- Lip of globe is completely protected against breakage by a **steel protector ring.**
- Provides **ceiling illumination** as well as **evenly distributed floor lighting.**
- Minimum amount of metal, maximum amount of glass results in **highest light efficiency.**

Here is a unique ceiling pan fixture design for either commercial or residential installation. For further information send for The Perfeclite Data Sheet 56-C today.

Perfeclite's new hammer lock fixture is available in the following sizes:

Model	Glass Diameter	Wattage
HH-9	8″	2- 40 W
HH-11	10″	2- 60 W
HH-13	12″	2- 75 W
HH-15	14″	2-100 W
HH-17	16″	3-100 W

Send for new Perfeclite Catalog 956 giving full information on our entire line of Commercial Incandescent Fixtures and Exit Units.

Fixtures are Underwriters Laboratories, Inc. approved.

*Patent pending

THE PERFECLITE COMPANY

1457 East 40th Street • Cleveland 3, Ohio

☐ Please send me The Perfeclite Data Sheet 56-C.
☐ Please send me the new Perfeclite Catalog 956.

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Address.....

City.....State.....

PERFECLITE PRODUCTS
THE MARK OF LIGHTING SERVICE

Switch to this new General Electric

WHITE MERCURY LAMP

YOU can use the new General Electric *White Mercury* Reflector Lamps *in your present 400-watt mercury equipment* with no change or added investment in operating equipment.

1 GET UP TO 63% MORE LIGHT ON WORK FROM YOUR PRESENT FIXTURES: Because a brand new phosphor generates more white light than ever before you get from 7% to 63% more light on the work, depending upon the lamp type you are replacing. (See below).

2 GET UP TO 33% LOWER COST OF LIGHT IN YOUR EXISTING INSTALLATIONS: With this increased efficiency your unit cost of light can go down from 7% to 33%. (See below)!

3 GET LOWER INITIAL COST FOR NEW INSTALLATIONS: You can get *more* light from the same number of fixtures, or get *equal* light with up to ⅓ *fewer* fixtures!

You get all this with new General Electric *White Mercury* Reflector Lamps because of a specially designed strontium magnesium orthophosphate phosphor. This phosphor converts ultra-violet radiation into more white light than ever possible before. It's also an efficient reflector—sealed in against dirt and fumes.

Gain these advantages *now*. Replace your present mercury lamps with the new G-E H400 RW-1. Also available in the bulged tubular shape, the H400 EW-1. For more information write: General Electric Large Lamp Dept. IE-2, Nela Park, Cleveland 12, Ohio.

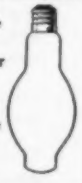
ADVANTAGES OF NEW G-E *WHITE MERCURY* OVER OTHER G-E 400-WATT MERCURY LAMPS

NEW RW-1 vs A-1 (clear glass)

- 55% to 63% more light to the work
- 27% to 33% lower cost of light
- Less maintenance
- Whiter "Color"

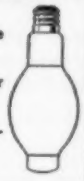
NEW RW-1 vs E-1 (clear glass)

- 28% to 31% more light to the work
- 16% to 23% lower cost of light
- Less maintenance
- Well suited for use in upward light fixtures
- Whiter "Color"



NEW RW-1 vs J1 (color improved)

- 37% to 40% more light on the work
- 24% to 30% lower cost of light
- Less color improvement

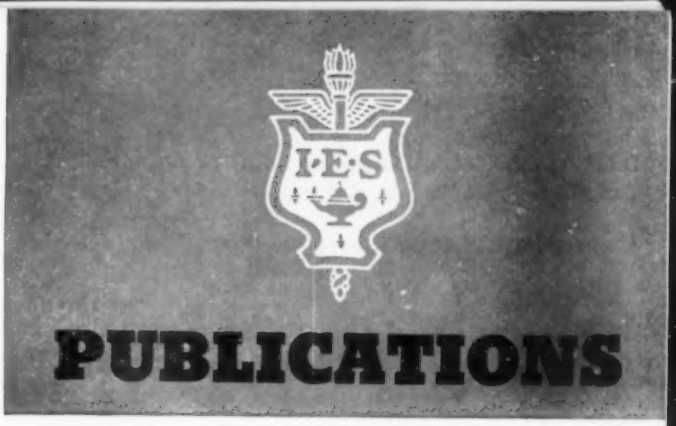


NEW RW-1 vs RC1 and R1 (reflector shape)

- About 7% more light on the work
- 7% lower cost of light
- Less color improvement for RC-1 users

Progress Is Our Most Important Product

GENERAL ELECTRIC



(Supersedes all lists prior to February 1957)

(1) I.E.S. LIGHTING HANDBOOK, Second Edition

LATEST! One volume, 987 pages. Published 1952. Complete revision of first edition includes basic information on all phases of lighting practice and technique, based upon recently developed standards. Contains 18 technical reference and application sections; complete appendices of information regularly used; 655 photos, drawings, lighting tables, charts; fully cross-indexed . . . over 4500 items. For use of lighting engineers and specialists, consultants, architects, designers . . . all who plan, install and manufacture lighting systems and equipment.

$8.00 per copy; $6.40 in lots of ten or more. Add 50c for shipment abroad. *I.E.S. Members are entitled to one copy of the Handbook at $5.50 unless previously ordered.*

I.E.S. RECOMMENDED LIGHTING PRACTICES

These booklets are the complete, standard recommendations for lighting the prescribed areas, and are among the most comprehensive and important of all Society publications. As indicated, some of these recommendations are the work of committees of the American Standards Association, with collaboration by appropriate committees of the I.E.S. All have the approval of the Council of the Illuminating Engineering Society, and are the latest official I.E.S. recommendations.

In general, the information contained in these Recommended Lighting Practices covers completely the area shown in the title. Included in the data are suggested types of lighting systems and luminaires; levels for general lighting and for specific areas; analyses of seeing tasks; and other information essential to lighting the area and of value to lighting engineers and specialists, architects, construction people and others. Each practice is fully illustrated with charts and photographs.

(2) OFFICE LIGHTING
I.E.S. Recommended Practice (1956) 50c

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Lighting recommendations based upon studies (research, surveys of current practice, and experimental installations) of I.E.S. Committees and Subcommittees covering all phases of lighting. Completely illustrated, these reports contain detailed information on many lighting problems peculiar to the industry or operation involved as well as providing general data as to lighting systems and luminaires; recommended quantity and quality of illumination; and analyses of specific seeing tasks.

The Publications of the Illuminating Engineering Society listed here summarize in printed form the vast amount of research, investigation and discussion of hundreds of qualified members of the Society working on technical committees. Each publication listed here is supported by the full authority and approval of the Illuminating Engineering Society.

I.E.S. Publications are available, in single copies or in bulk, to anyone requiring knowledge of the newest in lighting application and the supporting technical information. Should quantities be desired for distribution, such as for educational or promotional purposes, prices may be obtained by writing Publications Office.

Each publication is numbered for easy ordering by using the coupon on this page. Correspondence concerning publications should be addressed to: Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

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(Continued from page 18A)

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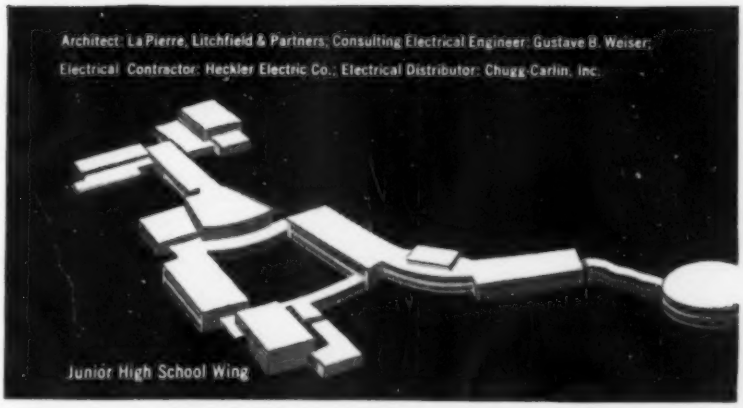
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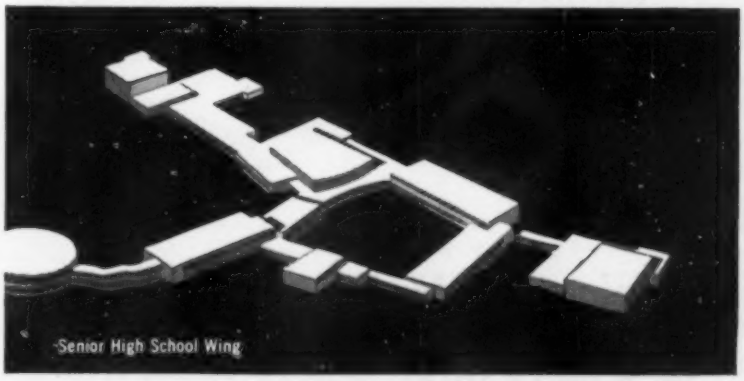

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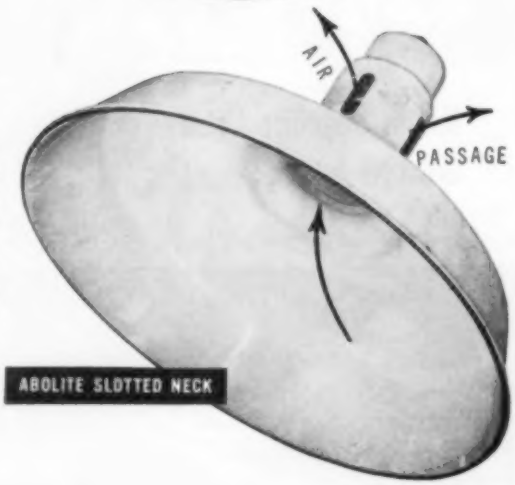

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(Continued from page 43A)

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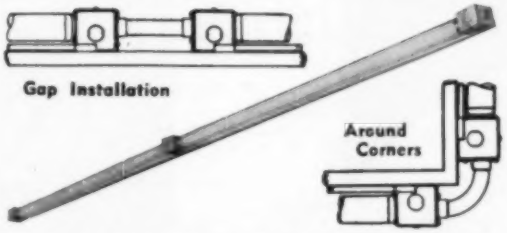

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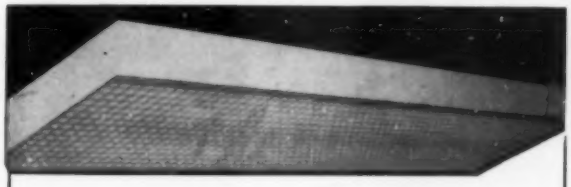

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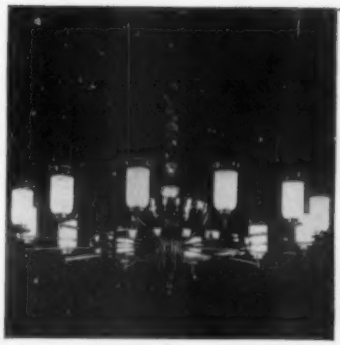

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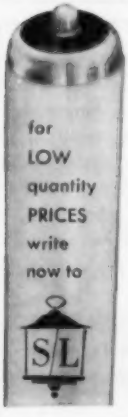

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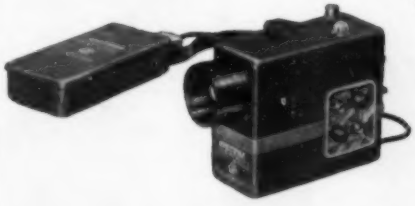

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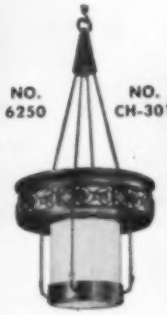

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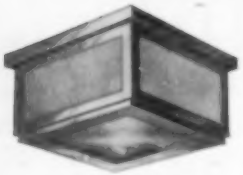

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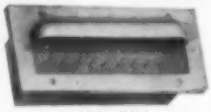

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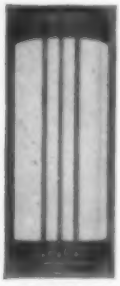

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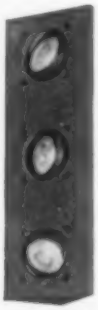

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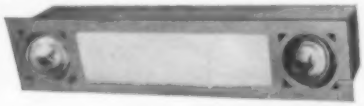

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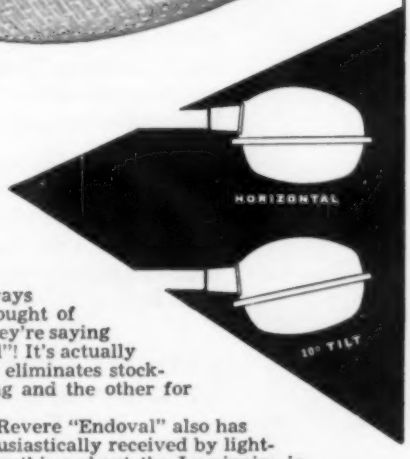

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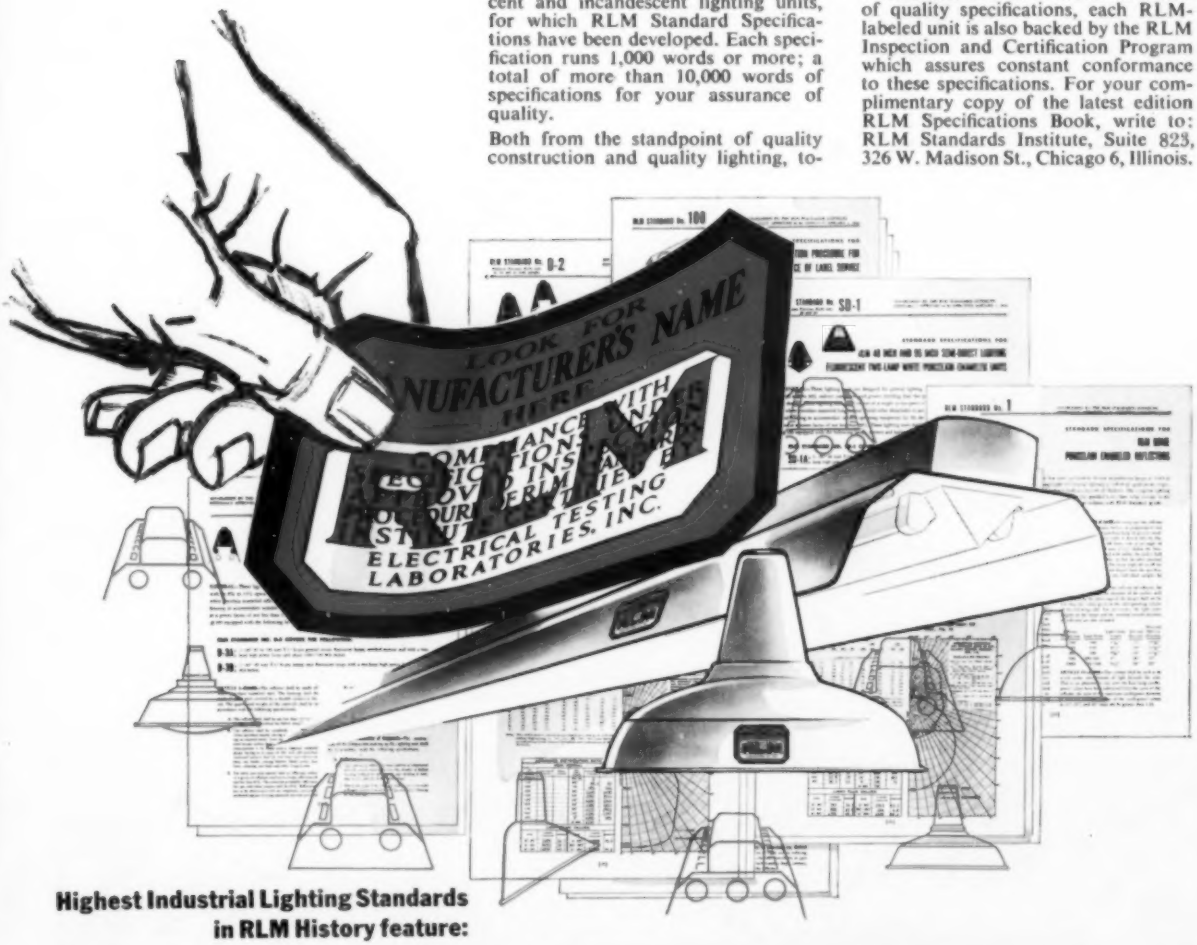

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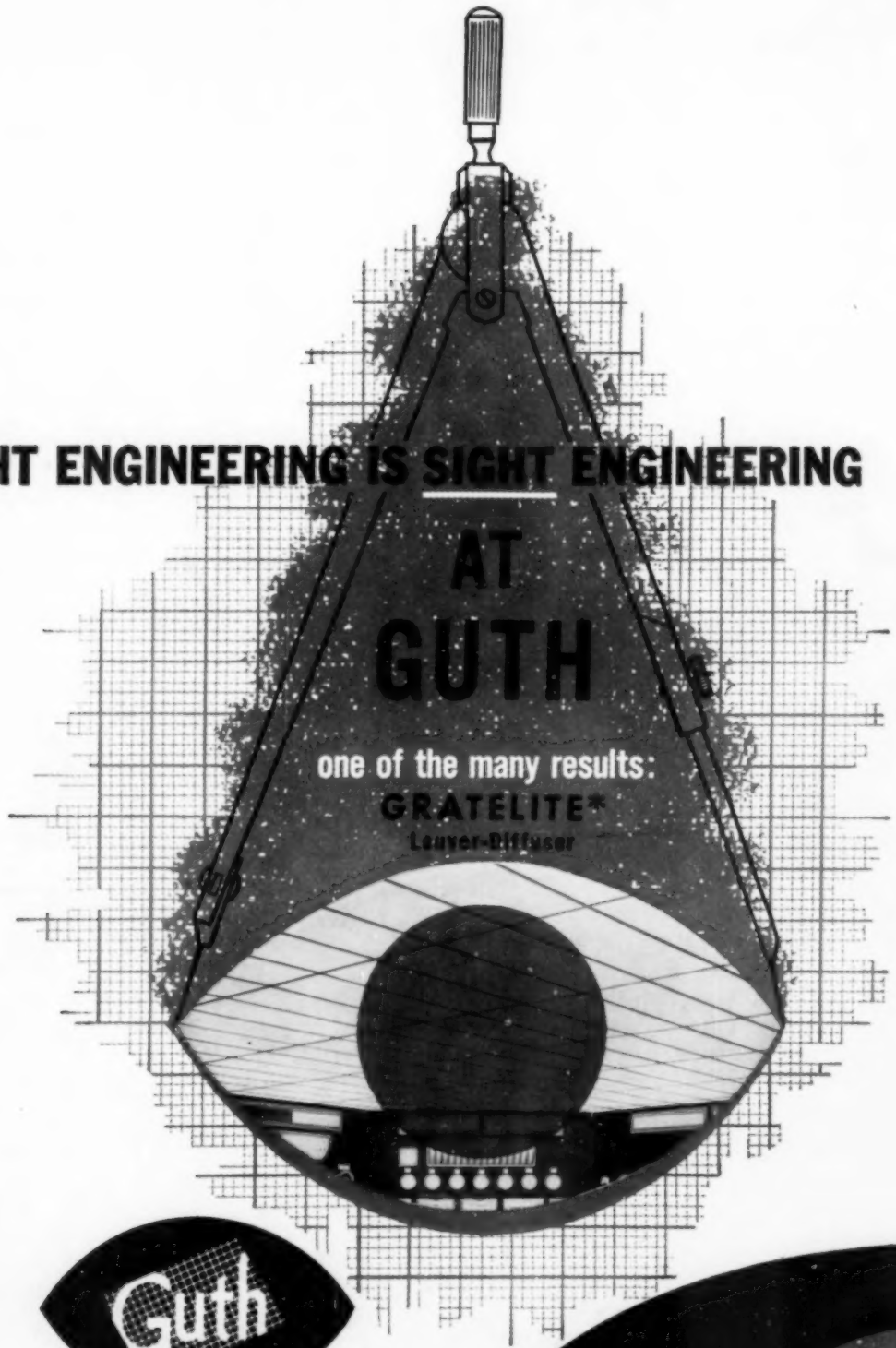

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